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Quality Assurance Project Plan

Former Building 9, Delphi-Flint West Facility

Flint, Michigan

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ARCADIS

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Quality Assurance Project Plan
Former Building 9, Delphi-Flint West Facility

Flint, Michigan

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Acronyms and Abbreviations

CLP	Contract Laboratory Program
COC	chain of custody
CQAP	Construction Quality Assurance Plan
CSMP	Containment System Monitoring Plan
CSOMP	Containment System Operation and Maintenance Plan
CSV	comma separated value
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
ft	feet
GIS	Geographic Information System
HASP	Health and Safety Plan
IDW	investigation-derived wastes
l	liters
l/min	liters per minute
MCL	Michigan Compiled Laws
MDEQ	Michigan Department of Environmental Quality
MDNRE	Michigan Department of Environment and Natural Resources
MPI	Materials Processing Incorporated
MS	Matrix Spike

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MSD	Matrix Spike Duplicate
NCP	National Contingency Plan
NEIC	National Enforcement Investigations Center
NIST	National Institute of Science and Technology
NREPA	Natural Resources and Environmental Protection Act
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PCB	polychlorinated biphenyl
PLC	programmable logic control
PPE	personal protective equipment
QAC	QA Coordinator
QAPP QA	Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource, Conservation, and Recovery Act
RFI	RCRA Facility Investigation
RPD	relative percent difference
SCB	soil-cement-bentonite
SDG	sample delivery group
SOP	Standard Operating Procedure
SOW	Scope of Work

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SVOC	semivolatile organic compound
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compound

1. Introduction

1.1 Overview

This document presents the Quality Assurance Project Plan (QAPP) for the monitoring environmental activities and sampling activities that Motors Liquidation Company (MLC) (formerly General Motors Corporation [GMC]) will perform at the Former Building 9 (the Site or property). Former Building 9 is part of the MLC owned property referred to as Flint West, which is located at the corner of Stevenson Street and Glenwood Avenue in Flint, Michigan (Figures 1 and 2). This QAPP has been developed on behalf of MLC by ARCADIS and is a component of the Facility Investigation Work Plan (Work Plan) that also includes a Field Sampling Plan (FSP) and a Health and Safety Plan (HASP). This QAPP presents the organization, objectives, and specific quality assurance / quality control (QA/QC) procedures associated with this Project. Protocols for sample collection, sample handling and storage, chain-of-custody procedures, and laboratory and field analyses are described or specifically referenced to related investigation documents. Standard operating procedures (SOPs) associated with environmental monitoring activities are included as **Appendix A**.

In June 2009, GMC declared bankruptcy and sold certain operating assets to a new company now known as General Motors LLC (GM LLC). MLC manages the remaining assets and obligations of GMC, in its capacity as debtor-in-possession. Flint West is currently owned and managed by MLC. It is expected that MLC will be dissolved in 2011 and that responsibility for this property and project will be transferred to the Environmental Response Trust.

This QAPP addresses the QA/QC elements in the USEPA Region 5 QAPP policy presented in the "USEPA RCRA QAPP Instructions" dated April 1998 and other relevant guidance documents, including "The Use of Field Methods to Support RFI Streamlining", USEPA Region 5 Memorandum, June 20, 1999. The QA/QC procedures described in this QAPP are consistent with USEPA guidance.

1.2 QAPP Purpose and Objectives

This QAPP presents data collection and QA requirements for environmental data to be collected during the environmental investigation and monitoring activities including groundwater and soil sampling as well as monitoring well installation. Environmental

data collection activities associated with the environmental monitoring, as presented in the Work Plan, include the following:

- Installation of borings;
- Soil sampling;
- Installation of groundwater monitoring wells;
- Groundwater sampling;
- Groundwater level gauging
- Surveying; and
- Non-aqueous phase liquid (NAPL) monitoring in both soil and groundwater.

1.3 QAPP Preparation

This QAPP was prepared consistent with the following reference and guidance documents:

- American National Standard. *Quality Systems for Environmental Data and Technology Programs – Requirements with Guidance for Use*. ANSI/ASQC E4-2004. (American National Standard, 2004);
- United States Environmental Protection Agency (USEPA) guidance document entitled *USEPA Requirements for QA Project Plans,* USEPA-QA/R-5 (USEPA, 2001a), which replaces QAMS-005/80, *Interim Guidance and Specifications for Preparing QA Project Plans* (USEPA, 1980);
- USEPA *Guidance for Quality Assurance Project Plans*, USEPA QA/G-5 (USEPA, 2002b); and
- MDNRE Remediation Redevelopment Division (RRD) Operational Memorandum No. 2, Sampling and Analysis, dated October 22, 2004.

1.4 QAPP Modifications

Under separate cover, MLC has submitted an investigation Work Plan to the USEPA for work at the Flint West property. Any future work plans submitted to USEPA will be executed in accordance with this QAPP or any subsequent revisions. Future revisions to this document may be required, if monitoring plans are refined or adjusted during the project due to the complexity and nature of the activities conducted at the site. In accordance with USEPA guidance document entitled USEPA Requirements for QA Project Plans, USEPA-QA/R-5 (USEPA, 2001a), established document revision procedures will be followed. The QAPP will be revised if there are changes as determined by the MLC Project Manager (or by persons with delegated authority) that significantly impact the technical and quality objectives of the project. When a revision to the QAPP is warranted, MLC (or the MLC's contractor) shall modify the QAPP to document the change and submit the revision for USEPA approval. Changes will only be implemented by MLC or MLC's contractors after acceptance by the USEPA. To facilitate control of the document and to ensure that the most recent version is used by all project participants, a document control format will be used on each page. The document control format is found in the upper right corner of each page and consists of the project name, document title, revision number, and revision date.

2. Project Organization

2.1 Project Organization

Sampling activities performed at the Site will require communications among personnel from the organizations identified below, collectively referred to as the "project team." A description of the responsibilities of each member of the project team regarding data quality assurance is presented below.

MLC Contractor's will perform related sampling activities and will evaluate data and prepare the deliverables as specified in the Work Plan or as otherwise required by MLC to safely and effectively implement the investigation. Project direction will be provided by ARCADIS, with oversight of certain sampling activities by the USEPA. A list of key project management personnel is provided below.

Company/Organization	Title	Name	Phone Number
USEPA	Project Manager	Chris Black	(312) 886-1451
USEPA	Region 5 On-Scene Coordinator	NA	
USEPA	RCRA Corrective Action Unit Chief	George Hamper	(312) 886-0987
MLC	Project Manager	David Favero	(271) 522-6714
ARCADIS	Project Officer	Chris Peters	(810) 225-1905
ARCADIS	Project Manager	Wendy White	(810) 225-1919
ARCADIS	Quality Control Coordinator	Dennis Capria	(315) 671-9299
Analytical Laboratory			
Merit Laboratories	Project Manager	Maya Murshak	(517) 332-0167
Merit Laboratories	QA Manager	TBD	(517) 332-0167

2.2 Team Member Responsibilities

The responsibilities of the various team members related to data quality assurance are summarized below by organization.

2.2.1 USEPA

Project Manager

Responsibilities and duties include:

Oversight of all phases of the activity on the MLC owned property.

The Project Manager is responsible for submitting this QAPP and any subsequent revisions or amendments to the appropriate USEPA personnel for review and approval, and for providing approval of the QAPP.

U.S. EPA RCRA Corrective Action Unit Chief

The U.S. EPA RCRA Corrective Action Chief has oversight responsibility for all activity on MLC owned property.

2.2.2 MLC

Project Manager

Responsibilities and duties include:

- Provide overall direction of Site actions,
- Direct MLC's contractors; and
- Review the contractor work products, including data, memoranda, letters, reports, and all other documents transmitted to the USEPA.

2.2.3 ARCADIS Project Organization

Project Officer

Responsibilities and duties include:

- Oversee work products.
- Provide approval for major project deliverables.

Project Manager

Responsibilities and duties include:

- Manage and coordinate the implementation of project work and monitoring activities with an emphasis on adhering to the requirements of the QAPP
- Review laboratory data reports.
- Review prepared documents.
- Report data quality concerns to the ARCADIS project manager.
- Verify that corrective actions are taken for deficiencies cited during any audits of Site activities.

Task Managers

The RFI components will be managed by various Task Managers. Duties of each Task Manager include, as appropriate:

- Manage relevant day-to-day activities.
- Develop, establish, and maintain files on relevant Site activities.
- Review data reductions from the relevant Site activities.
- Perform final data review of field data reductions and reports on relevant Site activities.
- Verify that corrective actions are taken for deficiencies cited during audits of relevant Site activities.

- Perform overall quality assurance/quality control (QA/QC) of the relevant portions of the Site activities.
- Review relevant field records and logs.
- Instruct personnel working on relevant Site activities.
- Coordinate field and laboratory schedules pertaining to relevant Site activities.
- Request sample bottles from laboratory.
- Review field instrumentation, maintenance, and calibration to meet quality objectives.
- Prepare reports pertaining to relevant Site activities.
- Maintain field and laboratory files of notebooks/logs, data reductions, and calculations. Transmit original files to the Project Manager.

Field Personnel

Responsibilities and duties include:

- Perform field procedures associated with the investigation as set forth in the work plan(s).
- Perform field analyses and collect samples for laboratory analysis, including QA samples.
- Calibrate, operate, and maintain field equipment.
- Reduce field data.
- Maintain sample custody.
- Prepare field records and logs.

Quality Assurance Coordinator

- Responsibilities and duties include:
- Review laboratory data packages.
- Oversee and interface with the analytical laboratory.
- Coordinate field QA/Quality Control (QC) procedures with Task Managers (including audits of field activities), concentrating on field analytical measurements and practices to meet data quality objectives (DQOs).
- Review field reports.
- Perform and review audit reports.
- Prepare interim QA/QC compliance reports.
- Prepare a QA/QC report in accordance with USEPA guidelines, including an evaluation of field and laboratory data and data usability reports.

2.2.4 Merit Laboratories

General responsibilities and duties of the analytical laboratories include:

- Supply sampling containers and shipping cartons.
- Maintain laboratory custody of sample.
- Perform sample analyses and associated laboratory QA/QC procedures.
- Strictly adhere to all protocols in the QAPP.
- Report any potential data quality concerns to the ARCADIS Project Manager.

Project Manager

Responsibilities and duties include:

- Serve as primary communication link between the Site Contractor and laboratory technical staff.
- Monitor workloads and maintain availability of resources.
- Oversee preparation of analytical reports.
- Supervise laboratory chain-of-custody.

Quality Assurance Manager

Responsibilities and duties include:

- Supervise personnel reviewing and inspecting all project-related laboratory activities.
- Conduct audits of all laboratory activities.

3. Project Background

3.1 Site Location and Description

Former Building 9 was approximately 80,897 square feet in size before its demolition in 1996. The Site is located at the corner of Stevenson Street and Glenwood Avenue in the city of Flint, Genesee County, Michigan. The Site is located in Section 12, Township 7 North, Range 6 East, as shown on the Flint North and Flint South U.S. Geological Survey (USGS) 7.5 minute series topographic quadrangle (Figure 1). The property is part of a series of approximately 40 buildings (most of which have been demolished) within the Flint West complex. The property is owned by MLC and a portion of the property is leased by Asylum Substation, which is owned by Consumers Energy.

The Site is zoned as a general industrial district. Adjacent properties are zoned general industrial as well as residential. The properties zoned immediately adjacent to the south (South of Glenwood Avenue) of the Flint West property are zoned as residential. The properties to the east, north, and west of the site are zoned industrial.

3.2 Site Background

Prior to its construction in 1929, the Site was a residential area. Former Building 9 was originally used as a mechanic shop and was eventually turned into an assembly line manufacturing plant that produced intake and exhaust engine valves. Processes which have been conducted at the site at Building 9 include: forging, plating, degreasing/parts cleaning, process wastewater collection and transport, lubrication, grinding/forming, welding, forming, heat treating and recycling, soluble lubricating oils treatment and recycling, and tumbling. These processes had potential to release contaminants into the environment. Since its initial construction, additional construction activities occurred twice at Building 9; the first was an addition in 1971 and the second was the construction of an overhand roof which was added to the north storage area in 1986. The building underwent decommissioning and demolition activities in 1996 and all manufacturing process machines have been removed in accordance with the facility deactivation plan. At the time of demolition, all machinery and wooden floor blocks were removed, the site was cleaned and filled, trenches and sumps were capped with concrete, and hazardous and non-hazardous materials were containerized for disposal or recycling.

The extent of potential impacts to the soil and groundwater of the Site were investigated and reported in various documents prepared on behalf of GM and the USEPA. Contaminants of concern (COCs) include volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals.

4. Project Description

This section presents the performance objectives of the investigation and describes the associated activities to be conducted at the site.

4.1 Objectives

The purpose of the investigation is to achieve the performance objectives associated with the Site described in the Work Plan. The performance objective of the investigation, stated in Section 1.6 of the Work Plan, is "…to fill the data gaps in order to define the nature and extent of contamination on and in the vicinity of the Site. The sampling locations proposed in this Work Plan are designed to define the impact of contamination from previous Site releases, so that appropriate response activities can be implemented."

4.2 Approach

As presented in the Work Plan, groundwater and soil chemical monitoring will be conducted to determine the effectiveness of the investigation in meeting the remedial objective of the project, which is ultimately preventing unacceptable exposure (both on-Site and off-Site) of contaminants released from the Site to humans and the environment. As specified in the Work Plan, groundwater and soil samples will be analyzed under the investigation groundwater chemical monitoring activities for the following analytical parameters:

Laboratory Parameters			Field Parameters
• Volatile Organic compounds • Polychlorinated biphenyls • Semi volatile organic compounds • Cyanide • Arsenic • Barium	• Cadmium • Chromium (Total) • Chromium (hexavalent) (water only) • Lead • Mercury • Nickel • Silver • Selenium • Zinc • Chloride	• Sulfate • Nitrate • Nitrite • Hardness (as $CaCo_3$) • Alkalinity • Ammonia • Total dissolved solids • Total organic carbon	• pH • Conductivity • Temperature • Turbidity • Oxidation Reduction Potential

4.3 Project Schedule

This QAPP and the Investigation Work Plan are submitted for approval to the USEPA. Following approval of these documents, the investigation activities will commence. The investigation activities will include:

- Soil Borings,
- Soil Sampling and Analysis,
- Monitoring Well Installation,
- Water Level Measurements,
- LNAPL measurements, as needed,
- Surveying, and
- Groundwater sampling and analysis.

Based upon a submittal date in late 2010, it is anticipated that the scope of the investigation and QAPP will be negotiated during the first quarter of 2011. Field work for the initial phase of the investigation will occur between April and June of 2011 and report submitted during the third quarter of 2011. A subsequent phase of investigation will be performed later in 2011 pending EPA review of the report for the initial investigation phase.

5. Quality Objectives and Criteria for Measurement Data

The Data Quality objectives (DQO) process, as described in Guidance for QA Project Plans (USEPA, 2002b), is intended to provide a "logical framework" for planning monitoring programs. This QAPP was prepared following the DQO process, which includes seven sequential steps in the USEPA's QAPP DQO process.

The seven-step DQO process defined by the USEPA is as follows:

Step 1: Problem Statement

Step 2: Decision Identification

Step 3: Identifying Decision Inputs

Step 4: Defining the Study Boundaries

Step 5: Developing a Decision Rule

Step 6: Limits on Decision Errors

Step 7: Design Optimization

DQOs for each type of data including groundwater monitoring well and LNAPL gauging, groundwater chemical monitoring, and soil sampling are required. Table 1 presents the DQO's for monitoring activities during the investigation program and incorporates the seven-step process. DQOs for the investigation activities will be refined upon development of the investigation work plan, and, if required, the QAPP will be modified.

A DQO summary for the investigation monitoring activities presented in the Work Plan is presented in the following section. The summary consists of stated DQOs relative to data uses, data types, data quantity, sampling and analytical methods, and data measurement performance criteria.

5.1 Data Categories

Three data categories have been defined to address various analytical data uses and the associated QA/QC effort and methods required to achieve the desired levels of quality. These categories are:

Screening Data: Screening data affords a quick assessment of Site characteristics or conditions. The associated DQO is applicable to data collection activities that involve rapid, non-rigorous methods of analysis and QA. This objective is generally applied to physical and/or chemical properties of samples, the degree of contamination relative to concentration differences, and preliminary health and safety assessment.

Screening Data with Definitive Confirmation: Screening data allow rapid identification and quantitation, although the quantitation can be relatively imprecise. The associated DQO is applicable to data collection activities that require qualitative and/or quantitative verification of a select portion of sample findings (10% or more). This objective can also be used to verify less rigorous laboratory-based methods.

Definitive Data: Definitive data are generated using analytical methods such as approved USEPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer-generated electronic files. DQOs for definitive data from chemical sampling activities for the RI will follow standard USEPA requirements.

Field parameters (e.g., turbidity, conductivity, temperature, pH) that will be obtained during water column sampling for use in qualitatively interpreting other Site data will be determined using screening techniques. All remaining parameters will be determined using definitive techniques.

For this project, full reporting will be used for the analysis and will require full documentation. This includes all groundwater or soil samples collected for laboratory chemical analysis.

The analytical work will be performed by MLC's contracted Laboratory, Merit Laboratories (Merit). The analytical results will be reported by Merit in the electronic data deliverable (EDD) format and in a PDF format (from data sheets) within 15 working days from date of receipt. The full data packages from the laboratory will be due within 45 working days from date of receipt.

5.2 Environmental Sample Analysis

Monitoring and sampling activities will be conducted to support the DQOs associated with the investigation performance objectives. Monitoring and sampling activities, operation and maintenance, and health and safety are presented in the Work Plan and the HASP.

Data Use – The data to be collected as described in the Work Plan will be used to ensure the performance objectives of the investigation are met.

Data Quantity – The sample quantities and parametric requirements for groundwater chemical monitoring are summarized in **Table 2**. Additional information regarding specific sample collection locations and required analyses can be found in the Work Plan and in Section 8 of this document.

Sampling and Analytical Methods – Sampling methods for groundwater chemical monitoring will be as specified in Section 9. The analytical methods are as specified in **Table 3**. Full documentation will be included in the data package for this project.

Data Comparability – Data representativeness is addressed by the sample quantities and locations identified in the Work Plan. Data comparability is intended to be achieved through the use of standard USEPA-approved methods.

6. Special Training Requirements/Certification

ARCADIS field sampling team members are required to have received the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) safety training and annual 8-hour refresher courses required by 29 CFR Parts 1910 and 1926. On-Site subcontractor personnel involved in invasive activities (e.g., drilling, excavation) are required to have received the same training. The subcontractor is responsible for compliance of their personnel with the applicable regulations.

Laboratory personnel training records are maintained at the laboratory. No special training or certification requirements are required for the laboratory for this project.

Persons in field supervisory positions will have also completed the additional OSHA 8-Hour Supervisory Training.

7. Documentation and Records

7.1 General

Required and appropriate environmental monitoring and sampling activities will be completed at the Site as part of the Investigation activities at the Site. Documentation, reporting, and record keeping will be performed consistent with Work Plan requirements. Specific documentation and reporting requirements are described below.

7.2 Sample Designation System

Samples will be identified with a unique designation system for unambiguous sample tracking. The sample designation system to be employed throughout the project will be consistent, yet flexible, to accommodate unforeseen changes where required. An alpha-numeric system will be used by field personnel to assign each sample with a unique sample identification number. The sample identification number will begin with a two-letter prefix indicating the sample type and digits indicating the sequential sample number collected starting at 100, followed by the date the sample was collected. For monitoring wells, in addition to the two-letter prefix, each sample identification number will have an "S" or "D" following the number to indicate whether the well is shallow or deep, respectively. Following the sample identification number will be the full date in parenthesis (e.g. MW-100S (10/26/2010).

The sample types potentially collected include the following and will be designated using the indicated codes in quotations:

- Monitoring Wells – "MW"
- Soil Boring – "SB"
- Trip Blank – "TB"
- Rinse Blank – "RB"
- Duplicate – "DP"
- Matrix Spike/Matrix Spike Duplicate – "MS/MSD"

Where necessary, the code system will be supplemented to accommodate additional sample identification information. For example, the code for soil samples collected from soil boring or monitoring well locations will include a qualifier to identify the section increment (e.g., 0 to 0.5 feet).

Additional sample volumes collected for matrix spike (MS) and matrix spike duplicate (MSD) analysis will be noted on the chain-of-custody forms, and the associated additional sample containers will be labeled accordingly. Field duplicates will be labeled as ordinary field samples with a unique identification number (e.g., the first field duplicate associated with soil collection would be named DUPSS01). Duplicate samples will not be identified, and the laboratory will analyze them as "blind" quality control samples.

7.3 Field Documentation

Field personnel will provide comprehensive documentation covering various aspects of field sampling, field analysis, and sample chain-of-custody. This documentation consists of a record that allows reconstruction of field events to aid in the data review and interpretation process. Documents, records, field log books, and other information relating to the performance of the field work will be retained in the contractor project file.

The various forms of documentation to be maintained throughout the project include:

- Daily Production Documentation -The personnel performing the field activities will keep field logs that detail all observations and measurements made during the Investigation. Data will be recorded directly into Site-dedicated, bound notebooks, with each entry dated and signed. So that it can be confirmed at any future date that notebook pages are not missing, each page will be sequentially numbered. Erroneous entries will be corrected by crossing out the original entry, initialing it, and then documenting the proper information. In addition, certain media sampling locations will be surveyed to accurately record their locations. The survey crew will use their own field logs and will supply the sampling location coordinates to the Task Manager. A more detailed discussion of field logs is provided in Section 10.2.1.

- Sampling Documentation - Detailed notes will be made as to the exact sampling location, physical observations, and weather conditions (as appropriate).

- Sample Chain-of Custody (COC) - COC forms are used as a means of documenting and tracking sample possession from time of collection to the time of disposal by the laboratory. A COC form will accompany each field sample collected, and one copy of the form will be filed in the field office. All field personnel will be trained on the proper use of the COC procedure. COC forms will be filled out at each sampling site, at a group of sampling sites, or at the end of each day of sampling by the Site Contractor field personnel responsible for sample custody. In the event that samples are relinquished by the designated sampling person to other sampling or field personnel, the COC form will be signed and dated by the appropriate personnel to document the sample transfer. The original COC form will accompany the samples to the laboratory, and copies will be forwarded to the project files. A sample COC form is included in **Appendix B** of this QAPP. Additional details on COC forms are provided in Section 10.2.3.

  Persons will have custody of samples when the samples are in their physical possession, in their view after being in their possession, or in their physical possession and secured so they cannot be tampered with. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel.

- Field Equipment, Calibration, and Maintenance Logs - To document the calibration and maintenance of field instrumentation, calibration and maintenance logs will be maintained for each piece of field equipment that is not factory calibrated.

7.4 Laboratory Documentation Files

7.4.1 Laboratory Project Files

The laboratory will establish a file for project data. The file will include correspondence with MLC, ARCADIS, and the USEPA, faxed information, phone logs, and COC forms. The laboratory will retain project files and data packages for a period not less than 5 years.

7.4.2 Laboratory Logbooks

Workbooks, bench sheets, instrument logbooks, and instrument printouts will be used to trace the history of samples through the analytical process and to document important aspects of the work, including the associated quality controls. As such,

logbooks, bench sheets, instrument logs, and instrument printouts will be part of the permanent record of the laboratory.

Each page or entry will be dated and initialed by the analyst at the time of entry. Errors in entry will be crossed out in indelible ink with a single stroke, corrected without the use of white-out or by obliterating or writing directly over the erroneous entry, and initialed and dated by the individual making the correction. Pages of logbooks that are not used will be completed by lining out unused portions.

Information regarding the sample, analytical procedures performed, and the results of the testing will be recorded on laboratory forms or personal notebook pages by the analyst. These notes will be dated and will also identify the analyst, the instrument used, and the instrument conditions.

Laboratory notebooks will be periodically reviewed by the laboratory group leaders for accuracy, completeness, and compliance with this QAPP. All entries and calculations will be verified by the laboratory group leader. If all entries on the pages are correct, the laboratory group leader will initial and date the pages. Corrective action will be taken for incorrect entries before the laboratory group leader signs the laboratory notebooks.

7.4.3 Computer Tape and Hard Copy Storage by the Laboratory

All electronic files and deliverables will be retained by the laboratory for not less than 5 years; hard copy data packages (or electronic copies) will also be retained for not less than 5 years.

7.5 Data Reporting Requirements

Data will be reported both in the field and by the analytical laboratory, as described below.

7.5.1 Field Data Reporting

Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks or data sheets and/or on forms. Such data will be reviewed by the appropriate Task Manager for adherence to the required scope of work and for consistency. Data quality concerns identified as a result of this review will be discussed with the field personnel, corrected if possible, and

(as necessary) incorporated into the data evaluation process. If questions remain that may impact data utility or interpretations, such concerns will be raised to the attention of ARCADIS.

If applicable, field data forms and calculations will be processed and included in appendices to the appropriate reports (when generated). The original field logs, documents, and data reductions will be kept in the project file at the Site Contractor's office.

7.5.2 Laboratory Data Reporting

For all media, the laboratory is responsible for preparing full CLP-equivalent (Level 3) data packages for all laboratory analysis.

Data reports for all parameters will include, at a minimum, the following items:

Narrative – Summary of activities that took place during the course of sample analysis, including the following information:

- laboratory name and address;
- date of sample receipt;
- cross reference of laboratory identification number to contractor sample identification;
- analytical methods used;
- deviations from specified analytical protocols; and
- corrective actions taken including description of any reanalysis.

Included with the narrative will be any sample handling documents, including field and internal COC forms, air bills, and shipping tags.

Analytical Results – These will be reported according to analysis type and include the following information, as applicable:

- sample ID;

- laboratory ID;
- date of collection;
- date of receipt;
- date of preparation;
- date of analysis;
- analyst initials;
- equipment ID; and
- detection limits.

Sample results on the report forms will be corrected for dilutions. Soil and sediment data will be reported on a dry weight basis. Unless otherwise specified, all results will be reported uncorrected for blank contamination.

The data for CLP-equivalent reporting will be expanded to include supporting documentation necessary to provide a CLP-equivalent package. This additional documentation will include, but not be limited to, raw data required to recalculate any result, including instrument printouts and quantitation reports. The report also will include standards used in calibration and calculation of analytical results; sample extraction, digestion, and other preparation logs; standard preparation logs; instrument run logs; and moisture content calculations.

The analytical results will be reported by the laboratory in the EDD format outlined in **Table 3** and in a PDF format (datasheets) within 10 working days from date of receipt of the samples. The full data packages from the laboratory will be due within 20 working days from date of receipt of the samples.

7.6 MLC Project File

Project documentation including computer files will be placed in MLC's or ARCADIS' project files according to the Site Contractor's filing requirements for document management and retained as discussed in Section 16.4.6.

8. Sampling Process Design

This QAPP applies to the following sampling and monitoring activities:

- groundwater sampling
- groundwater level monitoring (water levels),
- subsurface soil sampling, and
- elevation and coordinate surveys

Sampling and monitoring to confirm the effectiveness of the investigation in meeting the primary investigation performance objective, which is preventing the migration of groundwater off-site and preventing the discharge of groundwater from the Site into the surface water within the Flint River and tributary waters, will be conducted according to the requirements described in the Work Plan. Elevation and coordinate surveys are discussed in the Work Plan, and the FSP, and health and safety is discussed in the HASP. The investigation sample design will be presented in the Investigation Work Plan, which will be prepared to guide field activities. Investigation sampling procedures will follow applicable requirements of this QAPP.

8.1 Groundwater Monitoring Well Network

A monitoring well network will be installed to be used for groundwater elevation, LNAPL thickness (if applicable), and chemical monitoring. The monitoring well network is presented in the Work Plan and includes the following wells:

Monitoring Wells in the Vicinity of Area of Concern 1(AOC-1) – Five shallow monitoring wells are anticipated to be installed around the former chrome plater at AOC-1.

Monitoring Wells in the Vicinity of Area of Concern-2 (AOC-2A & 2B) – Six shallow monitoring wells are anticipated to be installed in the area between the former TCE degreaser and the gravel area on the Northwest side of the Former Building 9.

Monitoring Wells in the Vicinity of Area of Concern-2 (AOC-3) – Up to 4 monitoring wells are anticipated to be installed within the former storm water sump and pump in the north storage area, where LNAPL had previously been observed.

8.2 Baseline Groundwater Chemical Monitoring

As specified in the Work Plan groundwater samples will be collected from the monitoring well network to determine groundwater quality. As specified in the Work Plan, if conditions warrant a modification to sampling procedures during the establishment of the baseline groundwater quality, MLC may submit a request to the USEPA for review and approval to modify the analytical parameters and/or sampling frequency.

All water sample laboratory analysis will follow laboratory SOPs presented in **Appendix C**. Additional discussion of chemical monitoring is presented in the Work Plan.

8.3 Groundwater Sampling Schedule

Tentatively, gauging and sampling of the existing and newly installed groundwater monitoring wells will be performed on a quarterly basis for the first year after project start up. After reviewing analytical data from these monitoring wells, the groundwater gauging and sampling events may be moved to a semi-annual and eventually annual basis. The frequency of gauging and sampling will be dependent on the degree of impact at the Site and any implemented treatment systems that may be installed.

8.4 Groundwater Level Monitoring

Semi-annual manual water level measurements will be collected from the monitoring wells on and near the Site. This data will be used to monitor groundwater levels which will be used to construct groundwater flow maps.

8.5 Elevation and Coordinate Surveys

The Site, including the Asylum Substation, has been recently surveyed by a licensed surveyor. For all surveys, MLC will require a calibration certificate signed by a licensed surveyor. All surveys will be conducted under the direction of a licensed surveyor.

9. Sample Method Requirements

9.1 Groundwater Sampling

Groundwater samples will be collected for baseline chemical analysis from the existing and newly install monitoring wells to establish baseline groundwater quality conditions to be used during corrective response activities, if necessary and to evaluate potential off-Site contaminant migration. Investigation sampling procedures will be presented in the Investigation Work Plan. All samples will be collected in accordance with MDNRE's Remediation and Redevelopment Division (RRD) Operational Memorandum No. 2, Sampling and Analysis (Op Memo 2) (MDNRE, 2004a). Op Memo 2 and the associated attachments that pertain to this investigation are presented in **Appendix D**. Groundwater samples collected from on and off-site monitoring wells will be collected using a peristaltic pump and disposable tubing to prevent cross contamination. Samples will be collected using the low-flow sampling technique. Field parameters including pH, specific conductivity, temperature, dissolved oxygen, oxidation-reduction potential, and turbidity will be recorded during purging to determine stabilization prior to sampling.

9.2 Soil Sampling

Soil samples will be collected in accordance with the MDNRE's RRD Op Memo 2 (MDNRE, 2004a). Soil samples for laboratory analysis will be collected from the 0-6 inch bgs interval because potential impacts were generally believed to be at the surface and soils are generally fine grained, therefore limiting the potential for downward migration of contaminants. Additional samples may be collected if impacted soil is encountered based on high PID readings and visual observations. If there is no evidence of impacted soil throughout the sample, an additional sample may be collected from the interval above the water table if deemed necessary. The samples will be field preserved with methanol for VOC analysis.

10. Sample Handling and Custody Requirement

10.1 Sample Containers and Preservation

Appropriate sample containers, volumes, preservation methods, and laboratory holding times for investigation samples are shown in **Table 3**.

The analytical laboratory will supply appropriate sample containers and preservatives, as necessary. The bottles will be purchased pre-cleaned according to USEPA Office of Solid Waste and Emergency Response (OSWER) Directive 9240.05A requirements. The field personnel will be responsible for properly labeling containers and preserving samples (as appropriate). Laboratories will add preservative prior to delivery to the sampling staff when possible. Sample labeling procedures are discussed in Section 10.2.2.

10.2 Field Custody Procedures

The objective of field sample custody is to protect samples from tampering from the time of sample collection through time of transport to the analytical laboratory. Persons will have custody of samples when the samples are in their physical possession, in their view after being in their possession, or in their physical possession, and secured so they cannot be tampered with. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel.

Field custody documentation consists of both field logbooks and field COC forms.

10.2.1 Field Logbooks

Field logbooks will provide the means of recording the data collecting activities that are performed. As such, entries will be described in as much detail as possible so that persons going to the Site could reconstruct a particular situation without reliance on memory.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel, but will be stored in a secure location when not in use. Each logbook will be identified by the project specific document number. The title page of each logbook will contain the following:

- person to whom the logbook is assigned;
- logbook number;
- project name;
- project start date; and
- end date.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather conditions, names of all sampling team members present, name of subcontractors on-site (if any), level of personal protection being used, and signature of the person making the entry will be provided. The names of visitors to the site and field sampling or investigation team personnel, as well as the purpose of their visit, will also be recorded in the field logbook.

Measurements made and samples collected will be recorded. Entries will be made in ink, with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark and initialed. Whenever a sample is collected or a measurement is made, a detailed description of the location of the station will be recorded. The number of the photographs taken, if any, will also be noted. All equipment used to make measurements will be identified, along with the date of calibration.

Samples will be collected following procedures presented in **Appendices D, E,** and **F**. The equipment used to collect samples will be noted, along with the time of sampling, sample description, depth at which the sample was collected, volume, and number of containers. Sample identification numbers will be assigned prior to sample collection. Field duplicate samples, which will receive an entirely separate sample identification number, will be noted under sample description.

10.2.2 Sample Labeling

Preprinted sample labels will be affixed to sample bottles prior to delivery at the sampling site. The following information is required on each sample label:

- sample number;

- project name;
- date collected;
- time collected;
- location;
- sampler;
- analysis to be performed; and
- preservative.

10.2.3 Field Chain of Custody Forms

Completed COC forms will be required for all samples to be analyzed. COC forms will be initiated by the sampling crew in the field. The COC forms will contain the unique sample identification number, sample date and time, sample type, preservation (if any), and analyses required. The original COC form will accompany the samples to the laboratory. Copies of the COC will be made prior to shipment (or multiple copy forms will be used) for field documentation. The COC forms will remain with the samples at all times. The samples and signed COC forms will remain in the possession of the sampling crew until the samples are delivered to the express carrier (e.g., Federal Express), hand delivered to a mobile or permanent laboratory, or placed in secure storage.

Sample labels will be completed for each sample using waterproof ink. The labels will include the information listed in Section 10.2.2, above. The completed sample labels will be affixed to each sample bottle and covered with clear tape.

Whenever samples are split with a government agency or other party, a separate COC will be prepared for those samples by that agency or party and marked to identify the party with whom the samples are being split. The person relinquishing the samples to the facility or agency should request the representative's signature on the separate COC acknowledging sample receipt. If the representative is unavailable or refuses, this is noted in the "Received By" or "Taken By" space.

10.3 Management of Investigation-Derived Materials and Wastes

Investigation-derived wastes (IDW) include soils, groundwater, materials, and personal protective equipment (PPE). These wastes are generated during drilling, sampling, excavation, and other investigation activities. The intent of managing IDW is to insure that impacted materials and media are not allowed to contaminate non-impacted materials and media. Where necessary to insure the safe, efficient, and environmentally protective performance of work, management of investigation-derived materials and wastes will be performed consistent with the Guide to Management of Investigation-Derived Wastes, 9345.3-03FS (USEPA, 1992).

10.4 Packing, Handling, and Shipping Requirements

Sample packaging and shipment procedures are designed so that the samples will arrive at the laboratory, with the COC, intact.

Samples will be packaged for shipment as outlined below:

- Securely affix the sample label to the container with clear packing tape.
- Check the cap on the sample container to confirm that it is properly sealed.
- Wrap the sample container with clear packing tape to prevent the label from becoming loose.
- Complete the COC form with the required sampling information and confirm that the recorded information matches the sample labels. NOTE: If the designated sampler relinquishes the samples to other sampling or field personnel for packing or other purposes, the sampler will complete the COC prior to this transfer. The appropriate personnel will sign and date the COC form to document the sample custody transfer.
- Using duct tape, secure the outside drain plug at the bottom of the cooler.
- Wrap sample containers in bubble wrap or other cushioning material.
- Place 1 to 2 inches of cushioning material at the bottom of the cooler.
- Place the sealed sample containers into the cooler.

- Place ice in plastic bags and seal. Place loosely in the cooler.
- Fill the remaining space in the cooler with cushioning material.
- Place COC forms in a plastic bag and seal. Tape the forms to the inside of the cooler lid.
- Close the lid of the cooler, lock, and secure with duct tape.
- Wrap strapping tape around both ends of the cooler at least twice.
- Mark the cooler on the outside with the shipping address and return address, affix "Fragile" labels, and draw (or affix) arrows indicating "this side up." Cover the labels with clear plastic tape.
- Place a signed custody seal over the sample cooler lid.

Samples will be packaged by the field personnel and transported as low-concentration environmental samples. Samples will be hand delivered or delivered by an express carrier within 48 hours of the time of collection. Shipments will be accompanied by the COC form identifying the contents. The original form will accompany the shipment; copies will be retained by the sampler for the sampling office records. If the samples are sent by common carrier, a bill of lading will be used. Receipts or bills of lading will be retained as part of the permanent project documentation. Commercial carriers are not required to sign off on the COC form as long as the forms are sealed inside the sample cooler, and the custody seals remain intact.

Sample custody seals and packing materials for filled sample containers will be provided by the analytical laboratory. The filled, labeled, and sealed containers will be placed in a cooler on ice and carefully packed to eliminate the possibility of container breakage.

10.5 Laboratory Custody Procedures

10.5.1 General

Upon sample receipt, laboratory personnel will be responsible for sample custody. The original field COC form will accompany all samples requiring laboratory analysis. The laboratory will use COC guidelines described in the USEPA guidance documents.

Samples will be kept secured in the laboratory until all stages of analysis are complete. All laboratory personnel having samples in their custody will be responsible for documenting and maintaining sample integrity.

10.5.2 Sample Receipt and Storage

Immediately upon sample receipt, the laboratory sample custodian will verify the integrity of the cooler seal, open the cooler, and compare the contents against the field COC. If a sample container is missing, a sample container is received broken, the sample is in an inappropriate container, or the sample has not been preserved by appropriate means, the ARCADIS Project Manager will be notified. The laboratory sample custodian will be responsible for logging the samples in, assigning a unique laboratory identification number to each sample, labeling the sample bottle with the laboratory identification number, and moving the sample to an appropriate storage location to await analysis. The project name, field sample code, date sampled, date received, analysis required, storage location, date, and action for final disposition will be recorded in the laboratory tracking system. Relevant custody documentation will be placed in the project file.

10.5.3 Sample Analysis

Analysis of an acceptable sample will be initiated by worksheets that contain all pertinent information for analysis. The analyst will sign and date the laboratory COC form when removing the samples from storage.

Samples will be organized into sample delivery groups (SDGs) by the laboratory. An SDG may contain up to 20 field samples (field duplicates, trip blanks, and rinse blanks are considered field samples for the purposes of SDG assignment). All field samples assigned to a single SDG will be received by the laboratory over a maximum of 7 calendar days and must be processed through the laboratory (preparation, analysis, and reporting) as a group. Every SDG must include a minimum of one site-specific MS/MSD pair, which shall be received by the laboratory at the start of the SDG assignment.

10.5.4 Sample Storage Following Analysis

Samples will be maintained by the laboratory for at least 1 month after the final report is delivered to the Site Contractor. The laboratory will be responsible for the eventual and appropriate disposal of the samples. The analytical laboratory will inform the Site

Contractor before any samples are disposed. Unused portions of the samples, sample extracts, and associated wastes will be disposed of by the laboratory in accordance with applicable rules and regulations, as specified in the SOP for waste disposal.

11. Analytical Method Requirements

11.1 Field Parameters and Methods

During investigation sampling activities, selected physical and chemical parameters will be measured. Field measurements include dissolved oxygen, pH, turbidity, and specific conductance. Field parameters and methods associated with investigation activities will be presented in the Investigation Work Plan.

Because field instrumental analytical methodology is continually being updated, field personnel are required to consult the manufacture's instruction manual of each piece of field equipment for operation procedures.

11.2 Laboratory Methods, Project Target Compounds, and Laboratory Detection Limits

The parameters that samples are to be analyzed for and the laboratory analytical methods are shown in **Table 3**. The laboratory methods listed in **Table 3** are taken from Attachment 1 of MDNRE Op Memo No. 2 (MDNRE, 2004).

Table 3 presents the analytes and their respective target detection limit (TDL). All TDLs presented are in accordance with MDNRE RRD Op Memo No. 2, Attachment 4 (MDNRE, 2004).

The methods listed in **Table 3** include the range of analyses expected to be performed. Analytical results for all analyses will be reported in units identified in **Table 3**.

The primary sources to describe the analytical methods to be used during the investigation are provided in the SOPs which are referenced in **Appendix C**. These documents include "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, U.S.EPA Office of Solid Waste, 3rd Edition and Promulgated Updates, 1986; and "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983. USEPA SW-846 methods with QA/QC and reporting deliverables requirements will be used for all analytes.

12. Quality Control Requirements

12.1 Quality Assurance Indicators

The overall QA objective for this QAPP is to develop and implement procedures for sampling, COC, laboratory analysis, instrument calibration, data reduction and reporting, internal QC, audits, preventive maintenance, and corrective action, such that valid data will be generated. These procedures are presented or referenced in the following sections. Specific QC checks are discussed in Section 12.2.

1. QA indicators are generally defined in terms of five parameters:
2. Representativeness;
3. Comparability;
4. Completeness;
5. Precision; and
6. Accuracy.

Each parameter is defined below. Specific objectives for the Site actions are set forth in other sections of this QAPP, as referenced below.

12.1.1 Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent Site conditions, and is dependent on sampling and analytical variability and the variability of environmental media at the Site. The actions have been designed to assess the presence of the chemical constituents at the time of sampling. Related project documents (Work Plan and HASP) present the rationale for sample quantities and location. This QAPP presents field sampling and laboratory analytical methodologies. The use of the prescribed field and laboratory analytical methods with associated holding times and preservation requirements are intended to provide representative data.

12.1.2 Comparability

Comparability is the degree of confidence with which one data set can be compared to another. Comparability between phases of the actions (if additional phases are required) will be maintained through consistent use of the sampling and analytical methodologies set forth in this QAPP, established QA/QC procedures, and the utilization of appropriately trained personnel.

12.1.3 Completeness

Completeness is defined as a measure of the amount of valid data obtained from an event and/or investigation compared to the total amount that was obtained. This will be determined upon final assessment of the analytical results, as discussed in Section 12.6.

12.1.4 Precision

Precision is a measure of the reproducibility of sample results. The goal is to maintain a level of analytical precision consistent with the objectives of the action. To maximize precision, sampling and analytical procedures will be followed. All work for the Site actions will adhere to established protocols presented in the QAPP. Checks for analytical precision will include the analysis of MS/MSDs, laboratory duplicates, and field duplicates. Checks for field measurement precision will include duplicate field measurements. Further discussion of precision QC checks is provided in Section 12.4.

12.1.5 Accuracy

Accuracy is a measure of how close a measured result is to the true value. Both field and analytical accuracy will be monitored through initial and continuing calibration of instruments. In addition, reference standards, MSs, spike blanks, and surrogate standards will be used to assess the accuracy of the analytical data.

12.2 Field Quality Control Checks

12.2.1 Field Measurements

To verify the quality of data using field instrumentation, duplicate measurements will be obtained and reported for all field measurements. A duplicate measurement will involve obtaining measurements a second time at the same sampling location.

12.2.2 Sample Containers

Certified-clean sample containers (I-Chem 300 Series or equivalent) will be supplied by the laboratory. Certificates of analysis will be filed in the project file.

12.2.3 Field Duplicates

Field duplicates will be collected from the different sampling media to verify the reproducibility of the sampling methods. Field duplicates will be prepared by placing well-homogenized aliquots (except samples for VOC analysis) from the same sample location into individual sample containers, which will then be submitted blind to the laboratory. Field duplicate water and soil for VOC analysis will constitute co-located samples rather than homogenized aliquots. In general, field duplicates will be analyzed at a 10% frequency (every 10 samples) for the chemical constituents. Table 2 provides an estimated number of field duplicates to be prepared for each applicable parameter and matrix.

12.2.4 Rinse Blanks

Rinse blanks are used to monitor the cleanliness of the sampling equipment and the effectiveness of the cleaning procedures. Rinse blanks will be prepared and submitted for analysis once per day per matrix. Rinse blanks will be prepared by filling sample containers with analyte-free water (supplied by the laboratory) that has been routed through a cleaned sampling device. When dedicated sampling devices or sample containers are used to collect the samples, rinse blanks will not be necessary.

12.2.5 Field Blanks

Field blanks will be collected only for the analysis of mercury by USEPA method 1631E. Field blanks will be prepared by pouring laboratory supplied distilled water into the appropriate sample container and will be submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. The frequency of the field blank sample will generally be at least one sample per sampling event.

12.2.6 Trip Blanks

Trip blanks will be collected only for the analysis of mercury by USEPA method 1631E and VOCs. Trip blanks will be prepared and supplied by the laboratory and will be

submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. The frequency of the trip blank sample will generally be at least one sample per cooler.

12.3 Analytical Laboratory Quality Control Checks

12.3.1 General

Internal laboratory QC checks will be used to monitor data integrity. These checks will include method blanks, MS/MSDs, spike blanks, internal standards, surrogate samples, calibration standards, and reference standards. Project quality control limits for duplicates and MSs are identified in **Table 4**. Laboratory control charts will be used to determine long-term instrument trends.

12.3.2 Method Blanks

Sources of contamination in the analytical process, whether specific analyses or interferences, must be identified, isolated, and corrected. The method blank will be completed internally by the laboratory. The method blank is useful in identifying possible sources of contamination within the analytical process. For this reason, it is necessary that the method blank be initiated at the beginning of the analytical process and encompass all aspects of the analytical work. As such, the method blank would assist in accounting for any potential contamination attributable to glassware, reagents, instrumentation, or other sources that could affect sample analysis. One method blank will be analyzed with each analytical series associated with no more than 20 samples.

12.3.3 MS/MSDs

MS/MSDs will be used to measure the accuracy of analyte recovery from the sample matrices and will be site-specific. MSD pairs will be analyzed at a 5% frequency (every 20 samples or once per sampling round, whichever comes first).

When MS recoveries are outside QC limits, associated control sample and surrogate spike recoveries will be evaluated, as applicable, to attempt to verify the reason for the deviation and to determine the effect on the reported sample results. **Table 4** presents an estimated number of MS and MSD analyses for each applicable parameter.

12.3.4 Surrogate Spikes

Surrogates are compounds that are unlikely to occur under natural conditions but that have properties similar to the analytes of interest. This type of control is primarily used for organic samples analyzed by gas chromatography/mass spectrometry (GC/MS) and GC methods and is added to the samples prior to purging or extraction. The surrogate spike is utilized to provide broader insight into the proficiency and efficiency of an analytical method on a sample-specific basis. This control reflects analytical conditions that may not be attributable to sample matrix.

If surrogate spike recoveries exceed specified QC limits (**Table 4**), the analytical results must be evaluated thoroughly in conjunction with other control measures. In the absence of other control measures, the integrity of the data may not be verifiable, and reanalysis of the samples with additional control may be necessary. Surrogate spike compounds will be selected utilizing the guidance provided in the analytical methods.

12.3.5 Laboratory Duplicates

For inorganics, laboratory duplicates will be analyzed to assess laboratory precision. Laboratory duplicates are defined as a separate aliquot of an individual sample that is analyzed as a separate sample. **Table 4** presents an estimated number of laboratory duplicates for each applicable parameter.

12.3.6 Calibration Standards

Calibration check standards analyzed within a particular analytical series provide insight regarding instrument stability. A calibration check standard will be analyzed at the beginning and end of an analytical series, or periodically throughout a series containing a large number of samples.

In general, calibration check standards will be analyzed after every 12 hours or more frequently, as specified in the applicable analytical method. If results of the calibration check standard exceed specified tolerances, samples analyzed since the last acceptable calibration check standard will be reanalyzed.

Laboratory instrument calibration standards will be selected utilizing the guidance provided in the analytical methods as summarized in Section 14.

12.3.7 Reference Standards/Control Samples

Reference standards are standards of known concentration and are independent in origin from the calibration standards. The intent of reference standard analysis is to provide insight into the analytical proficiency within an analytical series. This includes preparation of calibration standards, validity of calibration, sample preparation, instrument set-up, and the premises inherent in quantitation. Reference standards will be analyzed at the frequencies specified within the analytical methods.

12.4 Data Precision Assessment Procedures

Field precision is difficult to measure because of temporal variations in field parameters. However, precision will be controlled through the use of experienced field personnel, properly calibrated meters, and duplicate field measurements. Field duplicates will be used to assess precision for the entire measurement system, including sampling, handling, shipping, storage, preparation, and analysis.

Laboratory data precision will be monitored through the use of MS/MSD and laboratory duplicate sample analyses.

The precision of data will be measured by calculation of the relative percent difference (RPD) by the following equation:

$$RPD = \frac{(A-B)}{(A+B)/2} \times 100$$

Where:

A = Analytical result from one of two duplicate measurements

B = Analytical result from the second measurement

Precision objectives for duplicate analyses are identified in **Table 4**.

12.5 Data Accuracy Assessment Procedures

The accuracy of field measurements will be controlled by experienced field personnel, properly calibrated field meters, and adherence to established protocols. The accuracy of field meters will be assessed by review of calibration and maintenance logs.

Laboratory accuracy will be assessed via the use of MSs, surrogate spikes, and reference standards. Where available and appropriate, QA performance standards will be analyzed periodically to assess laboratory accuracy. Accuracy will be calculated in terms of percent recovery as follows:

$$\% \text{ Recovery} = \frac{A-X}{B} \times 100$$

Where:

A = Value measured in spiked sample or standard

X = Value measured in original sample

B = True value of amount added to sample or true value of standard

This formula is derived under the assumption of constant accuracy between the original and spiked measurements. Accuracy objectives for MS recoveries are identified in **Table 4**.

12.6 Data Completeness Assessment Procedures

Completeness of a field or laboratory data set will be calculated by comparing the number of valid sample results generated to the total number of results generated.

$$\text{Completeness} = \frac{\text{Number valid results}}{\text{Total number of results generated}} \times 100$$

As a general guideline, overall project completeness is expected to be at least 90%. The assessment of completeness will require professional judgment to determine data usability for intended purposes.

12.7 Proficiency Samples

Proficiency samples are samples from third parties with known composition and provided to many laboratories on a scheduled basis. Results from the samples are used to independently evaluate the competency of the laboratory to produce acceptable results and compare performance with peer laboratories. The laboratory may participate in proficiency sample studies on a biannual basis and have the provider of such samples report to MLC, ARCADIS, and the USEPA the results upon completion of the study. Deficiencies will be addressed through a corrective action process on an expedited schedule and results similarly reported.

13. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Testing and maintenance schedules have been developed for both field and laboratory instruments. A summary of the testing and maintenance activities to be performed is presented below.

13.1 Field Instruments and Equipment

Prior to each field sampling event, each piece of field equipment will be inspected to confirm that it is operational. If the equipment is not operational, it will be serviced prior to its use. All meters that require charging or batteries will be fully charged or have fresh batteries. If instrument servicing is required, it is the responsibility of the appropriate Task Manager or field personnel to follow the maintenance schedule and arrange for timely service. Field instruments will be maintained according to the manufacturers' instructions. Calibration frequency and results along with any maintenance needs will be recorded in the daily field log books kept by field personnel. Logbooks for each piece of equipment will be maintained in project records. The Task Managers will review calibration and maintenance logs.

All measuring and test equipment to be used in support of the investigation activities that directly affect the quality of the analytical data shall be subject to preventative maintenance measures that minimize equipment downtime. Equipment will be examined to certify that it is in operating condition prior to each field sampling event. This includes checking the manufacturer's operating manual to confirm that all maintenance requirements are being observed. Field notes from previous sampling events will be reviewed to verify that any prior equipment problems are not overlooked and that any necessary repairs to equipment have been carried out.

Field equipment returned from a site will be inspected to confirm that it is in working order. The inspection will be recorded in the logbook or field notebooks, as appropriate. It will also be the obligation of the last user to record any equipment problems in the logbook. Non-operational field equipment will either be repaired or replaced. Appropriate spare parts will be made available for field meters. Consultant-/subcontractor-owned or leased equipment maintenance will be in accordance with the manufacturer's instructions.

13.2 Laboratory Instruments and Equipment

13.2.1 General

Laboratory instrument and equipment documentation procedures include details of any observed problems, corrective measure(s), routine maintenance, and instrument repair (including information regarding the repair and the individual who performed the repair).

Preventive maintenance of laboratory equipment generally will follow the guidelines recommended by the manufacturer. A malfunctioning laboratory instrument will be repaired immediately by in-house staff or through a service call from the manufacturer.

13.2.2 Instrument Maintenance

Maintenance schedules for laboratory equipment adhere to each manufacturer's recommendations. Records reflect the complete history of each instrument and specify the time frame for future maintenance. Major repairs or maintenance procedures are performed through service contracts with the manufacturer or qualified contractors. Paperwork associated with service calls and preventative maintenance calls will be kept on file by the laboratory.

Laboratory Systems Managers are responsible for the routine maintenance of instruments used in the particular laboratory. Any routine preventative maintenance carried out is logged into the appropriate logbooks. The frequency of routine maintenance is dictated by the nature of samples being analyzed, the requirements of the method used, and/or the judgment of the Laboratory Systems Manager.

All major instruments are backed up by comparable (if not equivalent) instrument systems in the event of unscheduled downtime. An inventory of spare parts is also available to minimize equipment/instrument downtime.

14. Instrument Calibration and Frequency

14.1 Field Instruments and Equipment

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated at the intervals specified by the manufacturer or more frequently, and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. In the event that an internally calibrated field instrument fails to meet calibration/checkout procedures, it will be returned to the manufacturer for service. More detailed information will be provided in the specific manufacturer's instruction manuals prior to use. Equipment found to be out of tolerance during the period of use will be removed from the field, and measuring and testing activities performed using the equipment will be addressed via the corrective action system described in Section 17.4 of this QAPP.

Field instruments to be used for health and safety or environmental monitoring include:

- Air VOC monitoring for health and safety – Photo ionization detector (Mini-Rae 2000 or equivalent)
- Groundwater field parameters (pH, conductivity, temperature, dissolved oxygen) – YSI model 556 multi-parameter flow cell meter (or equivalent)
- Groundwater level monitoring – Solinst electronic water level meter (or equivalent)

Specific calibration procedures associated with operation and maintenance of these instruments are provided in the manuals for the equipment.

Field personnel are responsible for confirming that a master calibration/maintenance log is maintained following the procedures specified for each measuring device. Where applicable, each log will include, at a minimum, the following information:

- name of device and/or instrument calibrated;
- device/instrument serial/identification numbers;
- calibration method;
- tolerance;

- calibration standard used;
- frequency of calibration;
- date(s) of calibration(s); and
- name of person(s) performing calibration(s).

14.2 Laboratory Instrument and Equipment

When analyses are conducted according to USEPA SW-846 methods, the calibration procedures and frequencies specified in the applicable method will be followed, as noted in the attached SOPs (**Appendix C**). For analyses governed by SOPs, see the appropriate SOP for the required calibration procedures and frequencies in **Appendix C**. Records of calibrations will be filed and maintained by the laboratory. These records will be subject to QA audit. For all instruments, the laboratory will maintain trained repair staff with in-house spare parts or will maintain service contracts with vendors.

All standards used in the calibration of equipment are traceable, directly or indirectly, to National Institute of Standards and Technology (NIST). All standards received shall be logged into standard receipt logs maintained by the individual analytical groups. Each group will maintain a standards log that tracks the preparation of standards used for calibration and QC purposes.

15. Inspection/Acceptance Requirements for Supplies and Consumables

All supplies to be used in the field and laboratory will be available when needed. They will be free of target chemicals and interferences. All sample containers will be certified clean prior to use. All reagents will be tested prior to use with Site samples. All standards will be verified against a second source standard. The laboratory will follow a "first in/first out" procedure for the storage and use of all consumables to minimize the risk of contamination and degradation.

16. Data Management

Appropriate data management activities will provide for the accuracy and ready accessibility of all of the necessary data to meet the analytical and reporting objectives of the project. Due to the large amount of data that will be generated, a structured, comprehensive, and efficient program for management of data is necessary.

The data management program for this project includes field documentation and sample QA/QC procedures, methods for tracking and managing the data, and a system for filing all Site-related information. Established electronic and hard copy data management procedures will be employed to efficiently process the information collected such that the data are readily accessible and accurate on electronic and hard copy format. These procedures are described in detail in the following section.

The data management plan has four elements: 1) sample designation system; 2) field activities; 3) sample tracking and management; and 4) data management system.

16.1 Sample Designation System

A concise and easily understandable sample designation system is an important part of the project sampling activities. It provides a unique sample number that will facilitate both sample tracking and easy re-sampling of select locations to evaluate data gaps, if necessary. The sample designation system to be employed during the sampling activities will be consistent, yet flexible enough to accommodate unforeseen sampling events or conditions. A combination of letters and numbers will be used to yield a unique sample number for each field sampled collected, as outlined in Section 7.2.

16.2 Field Activities

Field activities designed to gather the information necessary to make decisions during the investigation process require consistent documentation and accurate record keeping. During Site activities, standardized procedures will be used for documenting field activities, data security, and QA. These procedures are described in further detail in the following subsections.

16.2.1 Field Documentation

Field documentation will be managed as discussed in Section 7.3

16.2.2 Field Deliverables

In order to maintain control of data quality collected in the field, three separate deliverables were required from each field event:

- Field Sample Key (FSK) EDD
- Field Data EDD
- Survey EDD

These deliverables will be uploaded to the database maintained by ARCADIS and ensures consistency with the Laboratory EDD. Although these documents are typically generated by hand using Microsoft Excel, after the sample event, an alternative solution offered by MLC's Information Management group, that may be used, is a program called EDGE. This system is utilized by a pocket PC with custom software which will record the necessary information and generate the EDDs during field activities. EDGE is installed to complement the field notebook documentation.

16.2.3 Data Security

Measures will be taken during the investigation activities to prevent samples and records from being lost, damaged, or altered. When not in use, all media containing project notes and sample data including field notebooks, computer storage disks and external hard drives, sample and monitoring forms, and cameras will be stored at the field office or locked in the field vehicle. Access to these files will be limited to the field personnel who utilize them.

16.3 Sample Management and Tracking

A record of all field documentation will be maintained to provide verification of the validity of data used in the site analysis. To effectively execute such documentation, specific sample tracking and data management procedures will be used throughout the sampling program.

Sample tracking will begin with the completion of COC forms, as summarized in Section 10.2.3. The completed COC forms associated with samples collected will be faxed to the ARCADIS Project Manager. Copies of all completed COC forms will be maintained in the field office. The laboratory will verify receipt of the samples

electronically (via email to the task manager or ARCADIS Project Manager) on the following day.

When analytical data are received from the laboratory, the QAC will review the incoming analytical data packages against the information on the COCs to confirm that the correct analyses were performed for each sample and that results for all samples submitted for analysis were received. Any discrepancies noted will be promptly followed up by the QAC.

16.4 Data Management System

In addition to the sample tracking system, a data management system will be implemented. The central focus of the data management system will be the development of a personal computer-based project database. The project database, to be maintained by ARCADIS database team members, will combine pertinent geographical, field, and analytical data for each sample. Information that will be used to populate the database will be derived from four primary sources: public/historical records, surveying of sampling locations, field observations, and analytical results. MLC requires that all data for their sites be managed on the EQuIS 5 data management system. This database will allow ARCADIS and MLC database team members to query the database and generate data tables for the project in a timely manner, preventing potential bottlenecks in generating the necessary deliverables for reports. Typically, training for the EQuIS 5 Enterprise takes 20 minutes and is accessible using LiveMeeting for those team members who may be unfamiliar with the software.

16.4.1 Computer Software

The database will be written in the EQuIS 5 database management system and will run on the Windows Operating System. Geographic Information System (GIS) applications will be developed in ESRI ArcGIS, with additional customization performed with Visual Basic. Tables and other database reports will be generated through EQuIS 5 and/or Microsoft® Excel and Microsoft® Word. These software products will be upgraded as necessary to maintain industrial and corporate standards.

16.4.2 Survey Information

Each location sampled as part of the investigation will be surveyed to provide accurate documentation of sample locations for mapping purposes; to facilitate the re-sampling

of select sampling locations during future monitoring programs, if needed; and for any additional activities. All survey data will be computed in NGVD 29 and converted to IGLD 85 for USEPA reporting. All field books associated with the surveying activities will be stored as a record of the project activities. A Survey EDD will be completed in the field to ensure data quality as mentioned previously in section 16.2.2.

16.4.3 Field Observations

An important part of the information that will ultimately reside in the data management system for use during the project will originate in the observations that are recorded in the field.

During each sampling event, appropriate field documentation will be prepared by the field personnel who performed the sampling activities. The purpose of the documentation is to create a summary and a record of the sampling event. Items to be included are the locations sampled, the sampling methodologies used, field measurements including pH, conductivity, turbidity data, blind duplicate and MS/MSD sample identification numbers, equipment decontamination procedures, personnel involved in the activity, and any noteworthy events that occurred. See Section 16.2.2 for further field documentation.

16.4.4 Analytical Results

Analytical results will be provided by the laboratory in both digital (EDD) and a hard copy format. The data packages will be examined to confirm that the correct analyses were performed for each sample submitted and that all of the analyses requested on the COC form were performed. If discrepancies are noted, the QAC will be notified and will promptly follow up with the laboratory to resolve any issues.

Each data package will be validated in accordance with the procedures presented in Section 20. Any data that do not meet the specified standards will be flagged pending resolution of the issue. The flag will not be removed from the data until the issue associated with the sample results is resolved. Although flags may remain for certain data, the use of those data may not necessarily be restricted.

Following completion of the data validation, the digital files will be used to populate the appropriate database tables. This format specifies one data record for each constituent for each sample analyzed. Specific fields include:

- sample identification number;
- date sampled;
- date analyzed;
- parameter name;
- analytical result;
- units;
- detection limit; and
- qualifier(s).

The individual EDDs, supplied by the laboratory in either an ASCII comma separated value (CSV) format or in a Microsoft® Excel worksheet, will be loaded into the appropriate database table via a custom-designed user interface Visual Basic program. Any analytical data that cannot be provided by the laboratory in electronic format will be entered manually. After entry into the database, the EDD data will be compared to the field information previously entered into the database to confirm that all requested analytical data have been received.

16.4.5 Data Analysis and Reporting

The database management system will have several functions to facilitate the review and analysis of the investigation data. Routines have been developed to permit the user to electronically scan a copy of the analytical data from a given site for a given media. Several output functions are also available that can be modified, as necessary, for use in the data management system.

A valuable function of the data management system will be the generation of tables of analytical results from the project databases. The capability of the data management system to directly produce tables reduces the redundant manual entry of analytical results during report preparation and precludes transcription errors that may occur otherwise. This data management system function creates a digital file of analytical results and qualifiers for a given media. The file can then exported into a table of rows and columns that can be transferred to word processing software (e.g., Microsoft®

Word) for final formatting and addition of titles and notes. Tables of analytical data will be produced as part of data interpretation tasks and the reporting of data to the EPA.

The data management system also has the capability of producing a digital file of select parameters that exists in one or more of the databases. This type of custom function is accomplished on an interactive basis and is best used for transferring select information into a number of analysis tools, such as statistical or graphing programs.

16.4.6 Document Control and Inventory (Archiving, Storage and Retrieval)

Project archiving, storage and retrieval of project documents, reports, records, and data (both hardcopy and electronic formats) will be managed according to MLC's requirements for document management. Documents, reports, records, and data will be retained for future reference and hardcopy formats of project documents will be maintained in ARCADIS' project files.

17. Assessment and Response Actions

17.1 General

Performance and systems audits will be completed in the field and laboratory during the investigation, as described below.

17.2 External Field Performance and System Audit Procedures

The following field performance and systems audits will be completed during this project.

The appropriate Task Manager will monitor field performance. Field performance audit summaries will contain an evaluation of field activities to verify that the activities are performed according to established protocols. The ARCADIS Project Manager will review field reports and communicate concerns to the Task Managers and/or field staff, as appropriate. The Project Manager will review the field blank rinse and trip blank data to identify potential deficiencies in field sampling and cleaning procedures. Systems audits comparing scheduled QA/QC activities from this QAPP with actual QA/QC activities completed will be performed. The appropriate Task Manager and Project Manager will periodically confirm that work is being performed consistent with this QAPP and the Work Plan.

External audits may be conducted by the USEPA at any time during the field operations. These audits may or may not be announced and are at the discretion of the USEPA QA Officer. The external field audits can include (but are not limited to) the following:

- sampling equipment decontamination procedures;
- sample bottle preparation procedures;
- sampling procedures and;
- procedures for verification of field duplicates; and field screening practices.

17.3 Laboratory Audits

External audits will be conducted as required, by appropriate QA personnel of the U.S. EPA Region 5 and may be conducted at least once prior to sampling and analysis activities.

External audits may include any of the following:

i. Review of laboratory analytical procedures;

ii. Laboratory on-site visits; and

iii. Submission of performance evaluation samples for analysis.

Failure of any of the above audit procedures can lead to laboratory disqualification, and another suitable laboratory will have to be chosen. An on-site review can consist of:

i. Sample receipt procedures;

ii. Custody, sample security, and log-in procedures;

iii. Review of instrument calibration logs;

iv. Review of QA procedures;

v. Review of log books;

vi. Review of analytical SOPs; and

vii. Personnel interviews.

A review of a data package from samples recently analyzed by the laboratory can include (but not be limited to) the following:

i. Comparison of resulting data to the SOP or method

ii. Verification of initial and continuing calibrations within control limits

iii. Verification of surrogate recoveries and instrument timing results

iv. Review of extended quantitation reports for comparisons of library spectra to instrument spectra, where applicable; and

v. Assurance that samples are run within holding times.

17.4 Corrective Action Procedures

17.4.1 Field Procedures

Corrective action is intended to address problems that arise by identification, recommendation, approval, and implementation of measures that counter unacceptable procedures or deficient quality control performance. Examples of situations that would require corrective actions are provided below:

- protocols as defined by the QAPP and Work Plan have not been followed;
- equipment is not in proper working order or is not properly calibrated;
- QC requirements have not been met; and
- issues resulting from performance or systems audits have not been resolved.

Project personnel will continuously monitor ongoing work performance in the normal course of daily responsibilities.

17.4.2 Laboratory Procedures

In the laboratory, when a condition is noted to have an adverse effect on data quality, corrective action will be taken so as not to repeat this condition. Condition identification, cause, and corrective action taken will be documented and reported to the appropriate Project Manager and QAC.

Corrective action may be initiated, at a minimum, under the following conditions:

- protocols as defined by this QAPP have not been followed;
- predetermined data acceptance standards are not obtained;
- equipment is not in proper working order or calibrated;

- sample and test results are not completely traceable;
- QC requirements have not been met; and
- issues resulting from performance or systems audits have not been resolved.

Laboratory personnel will continuously monitor ongoing work performance in the normal course of daily responsibilities. Corrective action is initiated at the point where the problem has been identified. At whatever level this occurs (analyst, supervisor, data review, or quality control), it is brought to the attention of the Laboratory QA Manager and, ultimately, the Laboratory Director. Final approval of any action deemed necessary is subject to the approval of the Laboratory Director.

Any corrective action deemed necessary based on system or performance audits, the analytical results of split samples, or the results of data review will be implemented. The corrective action may include sample re-extraction, re-preparation, re-analysis, cleanup, dilution, matrix modification, or other activities.

18. Reports to Management

18.1 General

The QAC will audit the implementation of the QAPP. Each project component will result in some type of QA report or, by its absence, will indicate that no significant QA or QC deviations occurred. Items that may result in a QA report include:

- changes or updates to the QAPP;
- deviations from QAPP or Investigation Work Plan specification;
- results of system and performance audits;
- significant QA/QC problems, recommended solutions, and the results of corrective actions; and
- limitations on the use of measurement data.

18.2 Field Reports

Reporting of the quality of field sample collection and field measurements will be the responsibility of the Task Manager or designee. Information from the field logbooks will be compiled, and a summary report on field activity QA will be prepared for the project file.

18.3 Laboratory Reports

The laboratory will maintain QA records related to analyses, QC, and corrective action. This information will be made available to the Project Manager upon request. Routine reporting will include documenting all internal QC checks performed for this project.

19. Data Reduction and Review

19.1 General

After field and laboratory data are obtained, the data will be subject to the following:

- reduction, or manipulation mathematically or otherwise into meaningful and useful forms;
- review;
- organization, interpretation, and reporting; and
- data validation.

19.2 Field Data Reduction and Review

19.2.1 Field Data Reduction

Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks or data sheets, and/or on forms. Such data will be reviewed for consistency by the appropriate Task Manager. Concerns identified as a result of this review will be discussed with the field personnel; corrected if possible; and, as necessary, incorporated into the data evaluation process.

19.2.2 Field Data Review

Field data calculations, transfers, and interpretations will be conducted by the field personnel and reviewed for accuracy by the appropriate Task Manager. Logs and documents will be checked for:

- general completeness;
- readability;
- usage of appropriate procedures;
- appropriate instrument calibration and maintenance;

- reasonableness in comparison to present and past data collected;
- correct sample locations; and
- correct calculations and interpretations.

19.3 Laboratory Data Reduction and Review

19.3.1 Laboratory Data Reduction

The calculations used for data reduction will be specified in each of the analytical methods referenced previously. Whenever possible, analytical data will be transferred directly from the instrument to a computerized data system. Raw data will be entered into permanently bound laboratory notebooks. The data entered must be sufficient to document all factors used to arrive at the reported value.

Concentration calculations for chromatographic analyses will be based on response factors. Quantitation will be performed using either internal or external standards.

Inorganic analyses will be based on regression analysis. Regression analysis is used to fit a curve through the calibration standard data. The sample concentrations will be calculated using the resulting regression equations.

Nonaqueous values will be reported on a dry-weight basis. Unless otherwise specified, all values will be reported uncorrected for blank contamination.

19.4 Laboratory Data Review

Data will be subject to multi-level review by the laboratory. The Laboratory Project Manager will review all data reports prior to release for final data report generation. The QA Manager will review the final data reports prior to shipment.

If discrepancies or deficiencies are present in the analytical results, corrective action will be taken, as discussed in Section 17. Deficiencies discovered as a result of internal data review, as well as the corrective actions to be used to rectify the situation, will be documented on a Corrective Action Form provided by the Analytical Laboratory. This form will be submitted to the ARCADIS Project Manager.

19.5 Data Validation and Verification

All laboratory data generated will be subjected to the data validation and verification procedures outlined in Section 20. Data generated for disposal purposes will not be reviewed.

20. Data Validation and Verification

Data validation entails a review of the QC data and the raw data to verify that the laboratory was operating within required limits; the analytical results were correctly transcribed from the instrument read-outs; and which, if any, environmental samples were related to out-of-control QC samples. The objective of data validation is to identify any questionable or invalid laboratory measurements.

A designated data validator will validate all analytical data generated for groundwater samples and any soil samples using the versions of the USEPA's Function Guidelines (USEPA, 1999; 2002a) and USEPA Region *Innovative Approaches to Data Validation*, USEPA Region III (June 1995) for data validation available at the time of project initiation, where appropriate. The data review (Tier II) utilizing M-2 (organic) and IM-1 (inorganic) will be performed on 100% of the laboratory QC summary data deliverables. These procedures and criteria may be modified, as necessary, to address project-specific and method-specific criteria, control limits, and procedures. Data validation will consist of data screening, checking, reviewing, editing, and interpretation to document analytical data quality and to determine whether the quality is sufficient to meet the DQOs. Any deviation from these procedures and criteria will be identified in the data report to the USEPA.

The ARCADIS Task Manager or Project Manager will verify that reduction of laboratory measurements and laboratory reporting of analytical parameters is in accordance with the procedures specified for each analytical method and/or as specified in this QAPP. Any deviations from the analytical method or any special reporting requirements apart from those specified in this QAPP will be detailed on COC forms.

Upon receipt of laboratory data, the following procedures will be executed by the ARCADIS Task Manager:

- evaluate completeness of data package;
- verify that field COC forms were completed and that samples were handled properly;
- verify that holding times were met for each parameter. Holding time exceedances, should they occur, will be documented. Data for all samples exceeding holding time requirements will be flagged as either estimated or rejected. The decision as to which qualifier is more appropriate will be made on a case-by-case basis;

- verify that parameters were analyzed according to the methods specified;
- review QA/QC data (i.e., confirm that duplicates, blanks, and spikes were analyzed on the required number of samples, as specified in the method and verify that duplicate and MS recoveries are acceptable);
- investigate anomalies identified during review. When anomalies are identified, they will be discussed with the Project Manager and/or Laboratory Manager, as appropriate; and
- if data appear suspect, investigate the specific data of concern. Calculations will be traced back to raw data. If calculations do not agree, the cause will be determined and corrected.

Deficiencies discovered as a result of the data review, as well as the corrective actions implemented in response, will be documented and submitted in the form of a written report addressing the following topics, as applicable to each method:

- assessment of the data package;
- description of any protocol deviations;
- failures to reconcile reported and/or raw data;
- assessment of any compromised data;
- overall appraisal of the analytical data; and
- table of site name, sample quantities, matrix, and fractions analyzed.

Resolution of any issues regarding laboratory performance or deliverables will be handled between the laboratory and the data validator. Suggestions for reanalysis may be made by the ARCADIS Project Manager at this point.

Data validation reports will be kept in the project file.

21. References

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TABLES

ARCADIS

Tables

Table 1

Quality Assurance Project Plan
Data Quality Objectives (DQOs) Following USEPA 7-Step Process
Former Building 9 - Delphi Flint West
Flint, Michigan

Data Type	Problem Statement	Decision	Inputs to Decision	Boundaries	Decision Rule	Limits on Decision Errors	Design Optimization
Groundwater Level Monitoring	Determine migration of constituents of concern (COCs) in groundwater, both vertically and horizontally.	Establish a monitoring well network to define groundwater flow direction. Paired wells will be necessary if groundwater flow exhibits a vertical component of flow.	Monitoring wells will be installed and head levels measured as proposed in the Work Plan and FSP. Initially the water table will be monitored, followed by deeper wells screened preferentially within permeable zones, if present.	The monitoring will be confined to the delineated impacts.	In the event that the groundwater flow direction at the Site is other than what was anticipated (north-northwest and possibly south-southeast), additional monitoring wells may need to be installed to properly monitor contaminant migration.	Water level readings will be used directly for quantitative determination of the head levels as long as equipment is operating within acceptable calibration ranges.	Data collection procedures are described in the FSP and QAPP.
Groundwater LNAPL Monitoring	LNAPL could be present in the subsurface requiring a response action under Michigan administrative rules.	Determine whether the monitoring well network is sufficient to define LNAPL distribution on the property.	Monitoring wells will be installed and LNAPL thicknesses measured as proposed in the Work plan and FSP.	The monitoring will be confined to the delineated impacts.	In the event that LNAPL is present at the limits of the monitoring well network, additional monitoring wells may need to be installed to fully characterize LNAPL in the subsurface.	LNAPL thickness readings will be used directly for quantitative determination of the approximate volume of LNAPL on-site as long as equipment is operating within acceptable calibration ranges.	Data collection procedures are described in the FSP and QAPP.
Groundwater Chemical Sampling	Groundwater could be impacted with hazardous constituents at levels detrimental to human health and the environment and limiting future land use unless remediated.	Determine the degree to which groundwater is impacted with hazardous constituents as determined by a comparison to Michigan Part 201 cleanup criteria.	Groundwater samples will be collected and analyzed as proposed in the Work plan and FSP.	The sampling will be confined to the delineated impacts.	In the event that groundwater impacts greater than Michigan Part 201 generic cleanup criteria are present at the edge of the monitoring well network, additional monitoring wells may need to be installed to fully delineate groundwater impacts.	Groundwater chemistry laboratory results will be used for quantitative determination as long as the results are properly validated per the QAPP.	Data collection procedures are described in the FSP and QAPP.
Soil Chemical Sampling	Soil could be impacted with hazardous constituents at levels detrimental to human health and the environment and limiting future land use unless remediated.	Determine the degree to which soil is impacted with hazardous constituents as determined by a comparison to Michigan Part 201 cleanup criteria.	Soil samples will be collected and analyzed as proposed in the Work plan and FSP.	The sampling will be confined to the delineated impacts.	In the event that soil impacts greater than Michigan Part 201 generic cleanup criteria are present, additional soil borings need to be installed to fully delineate soil impacts.	Soil chemistry laboratory results will be used for quantitative determination as long as the results are properly validated per the QAPP.	Data collection procedures are described in the FSP and QAPP.

Table 2

Quality Assurance Project Plan
Sample Quantities and Quality Control Frequencies
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Field Quality Control Analyses						Laboratory Quality Control Sample						Total
	Trip Blank		Rinse Blank[3]		Field Duplicate		Matrix Spike		Matrix Spike Duplicate		Lab Duplicate		
	frequency	number[1]	frequency	number	frequency	number[2]	frequency	number[2]	frequency	number[2]	frequency	number[2]	
Groundwater													
VOCs and SVOCs	1/cooler	5	NC	--	1/10	1	1/20	1	1/20	1	NC	--	8
Polychlorinated Biphenyls (PCBs)	NC	--	NC	--	1/10	1	1/20	1	1/20	1	NC	--	3
Metals (arsenic, barium, cadmium, chromium, nickel, lead, silver, selenium, and zinc)	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
Mercury	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
Cyanide	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
General Water Quality Parameters[4]	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
Soil													
VOCs and SVOCs	1/cooler	5	NC	--	1/10	1	1/20	1	1/20	1	NC	--	8
Polychlorinated Biphenyls (PCBs)	NC	--	NC	--	1/10	1	1/20	1	1/20	1	NC	--	3
Metals (arsenic, barium, cadmium, chromium, nickel, lead, silver, selenium, and zinc)	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
Mercury	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4
Cyanide	NC	--	NC	--	1/10	1	1/20	1	1/20	1	1/20	1	4

Notes:
1. Assuming a total of 5 coolers will be submitted to the laboratory during each sampling round.
2. Sample counts are per monitoring event assuming that groundwater samples are collected from all existing and newly installed wells, for a total of 9 and that soil sample counts are 2 per boring for a total of 18 samples.
3. It is assumed that dedicated sampling equipment will be used and rinse blanks are not required when dedicated sampling equipment is used.
4. General Water Quality Parameters - alkalinity, ammonia, chloride, nitrated/nitrite, sulfate, hardness, total dissolved solids, total organic carbon
5. NC = not collected

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
GROUNDWATER SAMPLES (ug/L)					
Volatile Organic Compounds (VOCs)					
1,2-Dichlorobenzene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
1,2-Dichloroethane	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
1,2-Dichloropropane	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Acetone	8260B	50	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Benzene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
cis-1,2-Dichloroethene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Chlorobenzene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Ethylbenzene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
m,p-Xylene	8260B	2	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Merthyl(tert)butylether (MTBE)	8260B	5	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Methylene chloride	8260B	5	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Naphthalene	8260B	5	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
o-Xylene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Styrene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Tetrachloroethene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Toluene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Trichloroethene	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Vinyl chloride	8260B	1	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days
Xylenes, total	8260B	3	2-40 ml VOA vials	cool to 4° C, HCl to pH<2 no headspace	14 days

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
Semi-Volatile Organic Compounds (SVOCs)					
2,4,6-Trichlorophenol	8270C	4	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
2,4-Dichlorophenol	8270C	10	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
2,4-Dimethylphenol	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
2-Chlorophenol	8270C	10	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Acenaphthene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
bis(2-Ethylhexyl)phthalate	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Carbazole	8270C	10	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Dibenzofuran	8270C	4	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Fluoranthene	8270C	1	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Fluorene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Hexachlorobutadiene (C-46)	8270C	0.05 [6]	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
m,p-Cresol	8270C	20	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
o-Cresol	8270C	10	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Pentachlorophenol	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Phenanthrene	8270C	2	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Phenol	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Acenaphthylene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Anthracene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Benzo(a)anthracene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Benzo(a)pyrene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Benzo(b)fluoranthene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
Benzo(k)fluoranthene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Benzo(ghi)perylene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Chrysene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Dibenzo(ah)anthracene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Indeno(1,2,3-cd)pyrene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Naphthalene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Pyrene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
2-Methylnaphthalene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
1-Methylnaphthalene	8270C	5	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Polychlorinated Biphenyls (PCBs)					
Total PCBs	8082A	0.2	2-1 liter amber glass	cool to 4° C	7 days to extraction 40 days to analysis
Metals					
Mercury	1631E	0.001	2-40 ml VOA vials	cool to 4° C	28 days
Arsenic	6020	5	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Chromium (hexavalent)	7196A	10	125 ml plastic	cool to 4° C	24 hours
Chromium (total)	6020	10	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Cadmium	6020	1	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Barium	6020	100	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Lead	6020	3	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Nickel	6020	20	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Selenium	6020	5	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Silver	6020	0.20	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Zinc	6020	50	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Inorganics and General Water Quality Parameters					
Chloride	300.0	1 mg/l	1 L plastic	cool to 4° C	28 days
Sulfate	300.0	1 mg/l	1 L plastic	cool to 4° C	28 days
Nitrate	300.0	0.1 mg/l	1 L plastic	cool to 4° C	48 hours
Nitrite	300.0	0.1 mg/l	1 L plastic	cool to 4° C	48 hours
Hardness	2340 Std Mtd	2 mg/l	125 ml plastic	cool to 4° C, HNO_3 to pH<2	6 months
Alkalinity	2320B	1 mg/l	1 L plastic	cool to 4° C	14 days
Ammonia	4500-NH3 D	0.02 mg/l	250 ml plastic	cool to 4° C, H_2SO_4 to pH<2	28 days
Total Dissolved Solids	2540C	1 mg/l	1 L plastic	cool to 4° C	7 days
Total Organic Carbon	EPA 415	1 mg/l	2-40 ml VOA vials	cool to 4° C, H_2SO_4 to pH<2	28 days
Cyanide	335.4/4500-CN-E	5	125 ml plastic	cool to 4° C, NaOH to pH>12	14 days

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
SOIL SAMPLES (ug/kg)					
Volatile Organic Compounds (VOCs)					
1,2-Dichlorobenzene	8260B	100	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
1,2-Dichloroethane	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
1,2-Dichloropropane	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Acetone	8260B	1000	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Benzene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
cis-1,2-Dichloroethene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Chlorobenzene	8260B	250	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Ethylbenzene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
m,p-Xylene	8260B	100	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Merthyl(tert)butylether (MTBE)	8260B	250	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Methylene chloride	8260B	100	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Naphthalene	8260B	330	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
o-Xylene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Styrene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Tetrachloroethene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Toluene	8260B	100	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Trichloroethene	8260B	50	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Vinyl chloride	8260B	40	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days
Xylenes, total	8260B	150	1-40 ml VOA vial 1-4 oz glass, wide mouth	cool to 4° C, MeOH in VOA	14 days

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
Semi-Volatile Organic Compounds (SVOCs)					
2,4,6-Trichlorophenol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
2,4-Dichlorophenol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
2,4-Dimethylphenol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
2-Chlorophenol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Acenaphthene	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
bis(2-Ethylhexyl)phthalate	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Carbazole	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Dibenzofuran	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Fluoranthene	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Fluorene	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Hexachlorobutadiene (C-46)	8270C	50 [6]	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
m,p-Cresol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
o-Cresol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Pentachlorophenol	8270C	20 [7]	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Phenanthrene	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Phenol	8270C	330	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Acenaphthylene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Anthracene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Benzo(a)anthracene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Benzo(a)pyrene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Benzo(b)fluoranthene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Benzo(k)fluoranthene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Benzo(ghi)perylene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]
Chrysene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Dibenzo(ah)anthracene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Indeno(1,2,3-cd)pyrene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Naphthalene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Pyrene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
2-Methylnaphthalene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
1-Methylnaphthalene	8270C	330	2-1 liter amber glass	cool to 4° C	14 days to extraction 40 days to analysis
Polychlorinated Biphenyls (PCBs)					
Total PCBs	8082A	0.2	1- 4 oz. glass, wide mouth	cool to 4° C	14 days to extraction 40 days to analysis
Metals					
Mercury	7471A	50	1- 4 oz. glass, wide mouth	cool to 4° C	28 days
Arsenic	6020	100	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Chromium (total)	6020	200	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Barium	6020	1,000	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Cadmium	6020	200	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Lead	6020	1,000	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Nickel	6020	1,000	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Selenium	6020	200	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Silver	6020	100	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Zinc	6020	1,000	1- 4 oz. glass, wide mouth	cool to 4° C	6 months
Inorganics					
Cyanide	335.4/4500-CN-E	100	1- 4 oz. glass, wide mouth	cool to 4° C	14 days

TABLE 3

Quality Assurance Project Plan
Sample Containers, Preseveration, Holding Times, Methods, and Target Reporting Limits
Former Building 9 - Delphi Flint West
Flint, Michigan

Parameter	Analytical Method[1]	Target Detection Limit[2]	Sample Container and Volume[3]	Preservation[4]	Maximum Holding Time[5]

Notes:

(1) United States Environmental Protection Agency. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Edition 3 (SW-846), Office of Solid Waste & Emergency Response.
(2) Michigan Department of Environmental Quality (MDEQ) Remediation and Redevelopment Division (RRD) Operational Memorandum No. 2 - Attachment 1, October 22, 2004. The target detection limit (TDL) for each parameter in the VOC and Base/Neutral/Acid groups varies. Refer to the Operational Memorandum to determine the TDL for each compound included in those groups.
(3) Sample container will be new, precleaned, and certified by manufacturer.
(4) Whenever possible, pre-preserved bottles will be used.
(5) Holding time measured from date of collection.
(6) For response activities under Part 201 and Part 213, if the GSI has been appropriately documneted to not be a relevant pathway, then a water reporting limit of 10 ug/l and soil reporting limit of 330 ug/kg is sufficient to valuate the most restrictive criteria for Hexachlorobutadiene.
(7) For response activities under Part 201 and Part 213, if the GSI and the drinking water have been documented to not be relevant pathways, then water and soil reporting limits of 20 ug/l and 800 ug/kg will be sufficient to evaluate the most restrictive criteria for pentachlorophenol.

NL = not listed in the Operational Memorandum No. 2
ml = milliliters
° C = degrees Celsius
ug/l = micrograms per liter
ug/kg = micrograms per kilogram
The table applies to initial investigations to characterize the Site. Additions to this table may be required depending upon results used to characterize the Site and future sample collection. Any such additions will be made in accordance with the MDEQ Operational Memorandum no. 2, Sampling and Analysis, dated October 22, 2004.

Table 4

Quality Assurance Project Plan
Analytical Quality Control Limits(1)
Former Building 9 - Delphi Flint West
Flint, Michigan

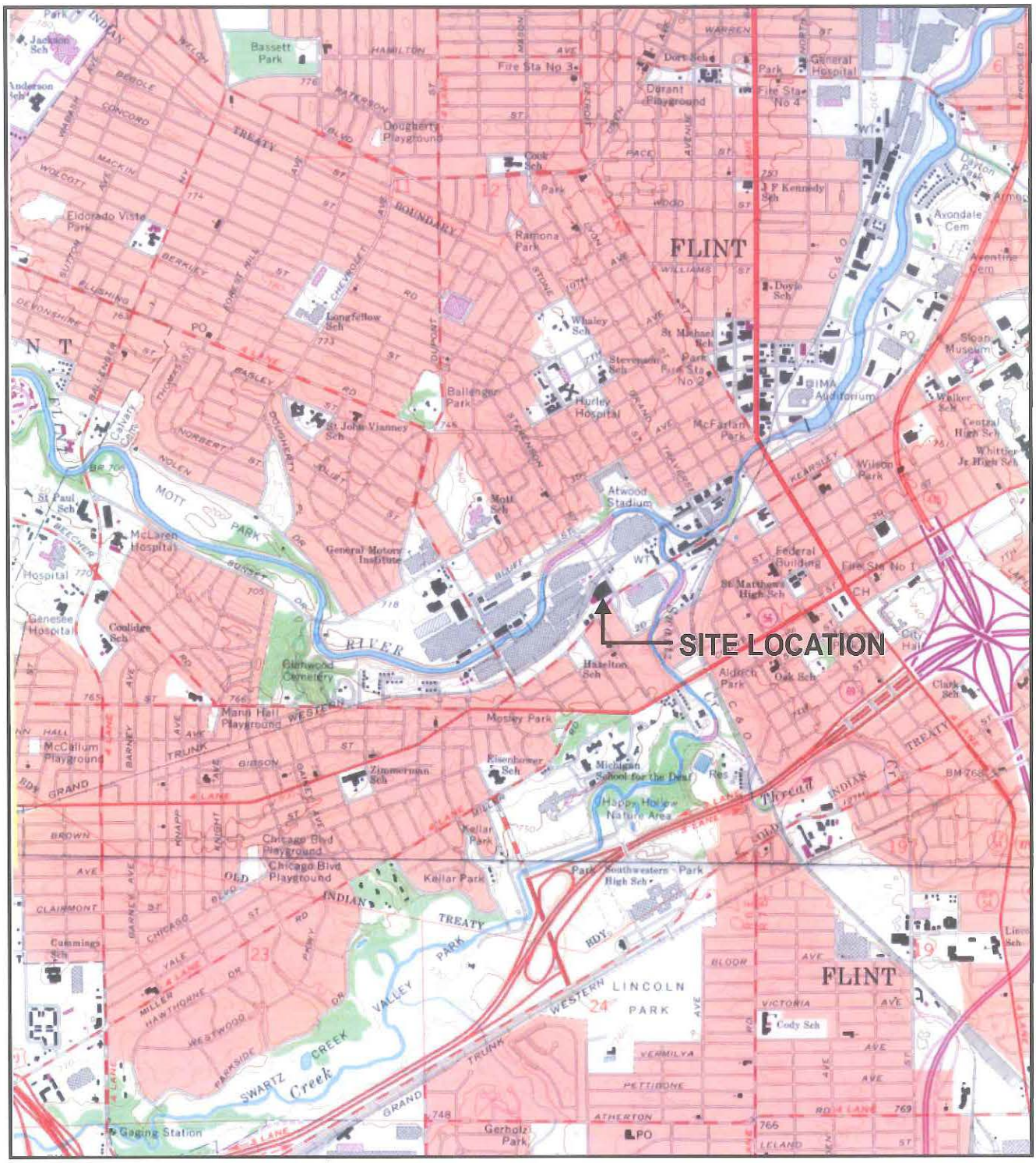
Parameter [2]	Accuracy - % Recovery			Precision - RPD		
	Surrogate	MS/MSD	LCS	MS/MSD	Lab Duplicate	Field Duplicate
Groundwater / Soil						
Volatile Organic Compounds (VOCs)	70-130	60-145	70-140	20	--	50
SVOCs	20-140	20-130	40-120	40	--	50
Polychlorinated Biphenyls (PCBs)	30-120	40-130	50-140	20	--	50
Metals (As, Ba, Cd, Total Cr, Ni, Pb, Hg, Ag, Se, Zn)	--	75- 125	75- 125	--	30	50
Cyanide, Available	--	75- 125	75- 125	--	30	50
Chromium (hexavalent)	--	65-121	70-130	--	30	50
Alkalinity	--	70-130	70-130	--	30	50
Ammonia	--	70-130	70-130	--	30	50
Chloride	--	70-130	70-130	--	30	50
Nitrate/Nitrite	--	70-130	70-130	--	30	50
Sulfate	--	70-130	70-130	--	30	50
Hardness	--	70-130	70-130	--	30	50
Total Dissolved Solids (TDS)	--	70-130	70-130	--	30	50
Total Organic Carbon (TOC)	--	70-130	70-130	--	30	50

Notes:
1 The listed QC limits are based on SW-846 guidance and are advisory. The actual limits are determined based on laboratory performance. Frequent failure to meet the QC limits however, warrant investigation of the laboratory.
2. Analysis for groundwater pH, groundwater conductivity, and oxidation/reduction potential will be analyzed using field methods only.
3. LCS - Laboratory Control Sample
4. RPD - Relative Percent Deviation
5. MS - Matrix Spike
6. MSD - Matrix Spike Duplicate

FIGURES

ARCADIS

Figures



MAP SOURCE: UNITED STATES GEOLOGIC SURVEY TOPOGRAPHIC QUADRANGLE, 7.5 MIN. SERIES,FLINT NORTH & FLINT SOUTH, MICHIGAN, (1969).

2000 0 2000

APPROXIMATE SCALE IN FEET

MOTORS LIQUIDATION COMPANY
FORMER BUILDING 9, DELPHI - FLINT WEST FACILITY
FLINT, MICHIGAN
QUALITY ASSURANCE PROJECT PLAN

SITE LOCATION MAP

ARCADIS

FIGURE 1

12/28/2010 SYRACUSE, NY-ENV/CAD - K.SARTORI
B0064605/2010/00002/CDR/64605N02.CDR

FORMER RAILROAD

FORMER DRINKING WATER WELL

MW-P9-5-4

AOC-2B
GRAVEL AREA
(N.W. SIDE OF BLDG.)

AOC-3
NORTH STORAGE AREA

STEVENSON STREET

MW-P9-3-2
MW-P9-3-3

STAIRS

MW-P9-4-3

FORMER BUILDING 9
(MLC)

SHADOWS

AOC-1
FORMER CHROME PLATER

SUBSTATION

MW-P9-5-5

ULTRASONICS

FORMER TCE DEGREASING UNITS
AOC-2A

SOUTH PARKING LOT

KEARSLEY STREET

GLENWOOD AVENUE

CHASE STREET

LEGEND

MW-P2A-3L ⊕	COMPLETED MONITORING WELL LOCATION
	POWER POLE
	STORM MANHOLE
	COVER PLATE
	MANHOLE
	POLE
	POST LIGHT POST
	MLC PROPERTY
	FORMER BUILDING LOCATION

0 30' 60'
GRAPHIC SCALE

MOTORS LIQUIDATION COMPANY
FORMER BUILDING 9 DELPHI FLINT WEST FACILITY
FLINT, MICHIGAN
BUILDING 9 QUALITY ASSURANCE PROJECT PLAN

EXISTING CONDITIONS MAP

ARCADIS

FIGURE 2

CITY: BRIGHTON DIV/GROUP: ENV/141 DB: ADF (SYR-KLS) LD: AM: PD: TM: TR: LYR:ON=*;OFF=*REF*
G:\ENVCAD\BRIGHTON\ACT\B0054605\20101000\02\dwg\646058d07.dwg LAYOUT: 2SAVED: 12/29/2010 1:25 PM ACADVER: 18.0S (LMS TECH) PAGESETUP: —PLOTSTYLETABLE: PLTFULL-CTB PLOTTED: 12/29/2010 1:25 PM BY: FOX, AARON
XREFS:
646058x02
IMAGES:
PROJECTNAME:

ARCADIS

Appendix A

ARCADIS Standard Operating Procedures

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Surface and Subsurface Soil Sampling Using Manual Methods

Rev. #: 1

Rev Date: March 6, 2009

Approval Signatures

Prepared by: _____ Date: 3/6/09

Reviewed by: _____ Date: 3/6/09
(Technical Expert)

I. Scope and Application

This document describes procedures for surface and subsurface soil sampling using hand tools.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading soil sampling activities should have a minimum of 2 years of previous environmental soil sampling experience. ARCADIS personnel providing assistance to soil sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences.

III. Equipment List

The following materials will be available, as required, during soil sampling activities:

- personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- stainless steel bowls;
- stainless steel spoons;
- stainless steel spades;
- stainless steel hand augers;
- indelible ink pens;
- engineer's ruler or survey rod;
- sealable plastic bags (e.g., Ziploc®);
- equipment decontamination materials
- sample bottles and preservatives appropriate for the parameters to be sampled for laboratory analysis, if any;
- transport container with ice (if sampling for laboratory analysis);
- appropriate sample containers and forms; and

- field notebook and/or personal digital assistant (PDA).

Documentation forms and notebooks to have on hand include: soil sample log forms, chain-of-custody forms, sample labels and seals, field logbook/PDA.

IV. Cautions / Hazards

Task specific Job Safety Analysis (JSAs) must be developed to identify site hazards associated with the investigation and reviewed by all field crew members prior to the start of work. Safe Performance Self-Assessment (SPSA) to be performed by employees before performing a new task. Underground utilities will be cleared per the ARCADIS Utility Location Policy and Procedure.

V. Health and Safety Considerations

Soil sample collection will be performed in accordance with a site-specific Health and Safety Plan (HASP) and task specific JSA forms, copies of which will be present on site during such activities.

VI. Procedure

Soil samples may be collected at intervals from the ground surface to various depths. Sample locations will be identified using stakes, flagging, or other appropriate means, and will be noted in a field logbook, PDA, and/or soil sampling logs. Sample points will be located by surveying, use of a global positioning system (GPS), and/or measurements from other surveyed site features.

1. Equipment that will come in contact with the soil sample should be cleaned in accordance with the appropriate equipment decontamination SOP(s), or else new, disposable equipment should be used. Collect equipment blanks in accordance with the project Quality Assurance Project Plan (QAPP).

2. Clear the ground surface of brush, root mat, grass, leaves, or other debris.

3. Use a spade, spoon, scoop, or hand auger to collect a sample of the required depth interval.

4. Use an engineer's ruler to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface.

5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval. To prevent the hole from collapsing, it may be

necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) tubing or pipe to maintain the opening.

6. Collect samples for volatile organic compounds (VOCs) as discrete samples using Encore® samplers or cut syringes (see Extraction/Preservation of Soil/Sediment Samples for VOCs SOP).

7. Homogenize samples for other analyses across the required interval or mix them with other discrete grab samples to form a composite sample (see Compositing or Homogenizing Samples SOP).

8. Place sample in clean sample container; label with sample identification number, date, and time of collection; and place on ice (if obtained for laboratory analysis). Prepare samples for packaging and shipping to the laboratory in accordance with the Chain-of-Custody Handling, Packing, and Shipping SOP.

9. Backfill sample holes to grade with native material or with clean builder's sand or other suitable material.

VII. Waste Management

Waste soils will be managed as specified in the FSP or Work Plan, and according to state and /or federal requirements. Personal Protective Equipment (PPE) and decontamination fluids will be contained separately and staged at the project site for appropriate disposal. Waste containers must be a sealed and labeled at the time of generation. Labels will indicate date, sample locations, site name, city, state, and description of the matrix (e.g., soil, PPE).

VIII. Data Recording and Management

Field documentation such as log book entries and chain-of –custody records will be transmitted to the ARCADIS PM or Task Manager each day unless otherwise directed. The field team leader will retain all site documentation while in the field and add to project files when the field mobilization is complete.

IX. Quality Assurance

Quality assurance samples (rinse blanks, duplicates, and MS/MSDs) will be collected at the frequency specified in the FSP and/or QAPP and depending on the project quality objectives. Reusable soil sampling equipment will be cleaned prior to use following equipment cleaning SOP. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site

conditions. Any deviations from the SOP will be discussed with the project manager prior to changing any field procedures.

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Water-Level and NAPL Thickness Measurement Procedures

Rev. #: 0

Rev Date: February 27, 2009

Approval Signatures

Prepared by: Andrew Korik Date: 2/27/09
Andrew Korik

Reviewed by: Michael J Gefell Date: 2/27/09
Michael Gefell (Technical Expert)

I. Scope and Application

Monitoring well water levels and thickness of non-aqueous phase liquids (NAPLs) will be determined, as appropriate, to develop groundwater elevation contour maps and to assess the presence or absence of NAPL in wells. This SOP applies to light and/or dense NAPLs (LNAPLs and DNAPLs, respectively). In addition, because this SOP describes water-level measurement from surveyed measurement points, this SOP can be followed, to obtain surface water level measurements from surveyed measurement points.

Fluid levels will be measured using an electric water-level probe and/or NAPL-water interface probe from established reference points. Reference points are surveyed, and are established at the highest point at the top of well riser, and will be based on mean sea level, or local/onsite datum. The Operating and Maintenance (O&M) Instruction Manual for the electric water level probe and/or and interface probe should be reviewed prior to commencing work for safe and accurate operation.

II. Personnel Qualifications

Individuals conducting fluid level measurements will have been trained in the proper use of the instruments, including their use for measuring fluid levels and the bottom depth of wells. In addition, ARCADIS field sampling personnel will have current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work. ARCADIS field personnel will also be compliant with client-specific training requirements, such as (but not limited to) LPS or other behavior-based training, and short-service employee restrictions.

III. Equipment List

The following materials, as required, shall be available during fluid level measurements.

- photoionization detector (PID)
- appropriate health and safety equipment, as specified in the site Health and Safety Plan (HASP)

- laboratory-type soap (Alconox or equivalent), methanol/hexane rinse, potable water, distilled water, and/or other equipment that may be needed for decontamination purposes
- electronic NAPL-water interface probe
- electronic water-level meter
- 6-foot engineer's rule
- portable containers
- plastic sheeting
- field logbook and/or personal digital assistant (PDA)
- indelible ink pen
- digital camera (optional, if allowed by site policy)

IV. Cautions

Electronic water-level probes and NAPL-water interface probes can sometimes produce false-positive readings. For example, if the inside surface of the well has condensation above the water level, then an electronic water-level probe may produce a signal by contacting the side of the well rather than the true water level in the well. In addition, NAPL-water interface probes can sometimes indicate false positive signals when contacting a sediment layer on the bottom of a well. In contrast, a NAPL-water interface probe may produce a false-negative (no signal) if a floating layer of non-aqueous phase liquid (NAPL) is too thin, such as a film or sheen. To produce reliable data, the electronic water level probe and/or interface probe should be raised and lowered several times at the approximate depth where the instrument produces a tone indicating a fluid interface to verify consistent, repeatable results. In addition, a bottom-loading bailer should periodically be used to check for the presence of NAPLs rather than relying solely on the NAPL-water interface probe.

The graduated tape or cable with depth markings is designed to indicate the depth of the electronic sensor that detects the fluid interface, but not the depth of the bottom of the instrument. When using these devices to measure the total well depth, the additional length of the instrument below the electronic sensor must be added to the apparent well depth reading, as observed on the tape or cable of the instrument, to obtain the true total depth of the well. If the depth markings on the tape or cable are

worn or otherwise difficult to read, extra care must be taken in obtaining the depth readings.

V. Health and Safety Considerations

The HASP will be followed, as appropriate, to ensure the safety of field personnel. Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or NAPL. Other potential hazards include stinging insects that may inhabit well heads, other biologic hazards, and potentially the use of sharp cutting tools (scissors, knife). Appropriate personal protective equipment (PPE) will be worn during these activities. Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

VI. Procedure

Calibration Procedures

If there is any uncertainty regarding the accuracy of the tape or cable associated with the electronic water-level probe or NAPL-water interface probe, it should be checked versus a standard length prior to use to assess if the tape or cable above the meter has been correctly calibrated by the manufacturer, and to identify evidence of tape or cable stretching, etc.

1. Measure the lengths between markers on the cable with a 6-foot engineer's rule or a fiberglass engineer's tape. The tape or cable associated with the electronic water-level probe or NAPL-water interface probe should be checked for the length corresponding to the deepest total well depth to be monitored during the data collection event.

2. If the length designations on the tape or cable associated with the electronic water-level probe or NAPL-water interface probe are found to be incorrect, the probe will not be used until it is repaired by the manufacturer.

3. Record verification of this calibration process in field logbook or PDA.

Measurement Procedures

The detailed procedure for obtaining fluid level depth measurements is as follows. Field notes on logs will be treated as secured documentation and indelible ink will be used. As a general rule, the order of measuring should proceed from the least to most contaminated monitoring wells, based on available data.

1. Identify site and well number in field logbook using indelible ink, along with date, time, personnel, and weather conditions.

2. Field personnel will avoid activities that may introduce contamination into monitoring wells. Activities such as dispensing gasoline into vehicles or generators should be accomplished well in advance of obtaining field measurements.

3. Don PPE as required by the HASP..

4. Clean the NAPL/water interface probe and cable in accordance with the appropriate cleaning procedures. Down-hole instrumentation should be cleaned prior to obtaining readings at the first monitoring well and upon completion of readings at each well.

5. Clean the NAPL/water level interface probe and cable with a soapy (Alconox) water rinse followed by a solvent rinse (if appropriate based on site-specific constituents of concern) an analyte-free water rinse Contain rinse water in a portable container that will be transferred to an on-site container.

6. Put clean plastic sheeting on the ground next to the well.

7. Unlock and open the well cover while standing upwind from the well. Place the well cap on the plastic sheeting.

8. Locate a measuring reference point on the well casing. If one is not found, initiate a reference point at the highest discernable point on the inner casing (or outer if an inner casing is not present) by notching with a hacksaw, or using an indelible marker. All down-hole measurements will be taken from the reference point established at each well on the inner casing (on the outer only if an inner casing is not present).

9. Measure to the nearest hundredth of a foot and record the height of the inner and outer casings (from reference point, as appropriate) to ground level.

10. Record the inside diameter of the well casing in the field log.

11. If an electronic water level probe is used to measure the water level, lower the probe until it emits a signal (tone and or light) indicating the top of the water surface. Gently raise and lower the instrument through this interface to confirm its depth. Measure and record the depth of the water surface, and the total well depth, to the nearest hundredth of a foot from the reference point at the top of

the well. Lower the probe to the bottom of the well to obtain a total depth measurement.

12. If a NAPL/water interface probe is being used to measure the depth and thickness of NAPL, lower the instrument until it emits a signal (tone and or light) indicating whether LNAPL is present. Continue to lower the NAPL/water level interface probe until it indicates the top of water. Lower the probe to the bottom of the well to obtain a total depth measurement. Note also of the depth indicating the bottom of water and top of DNAPL layer, if any, based on the signal emitted by the interface probe. At each fluid interface, gently raise and lower the instrument through each the interface to confirm its depth. Measure to the nearest hundredth of a foot and record the depth of each fluid interface, and the total well depth, from the reference point.

13. Clean the NAPL/water interface probe and cable in accordance with the appropriate cleaning procedures.

14. If using a bailer to confirm the presence/absence of NAPL, the bailer should either have been previously dedicated to the well, or be a new previously unused bailer.

15. Compare the depth of the well to previous records, and note any discrepancy.

16. Lock the well when all activities are completed.

VII. Waste Management

Decontamination fluids, PPE, and other disposable equipment will be properly stored on site in labeled containers and disposed of properly. Be certain that waste containers are properly labeled and documented in the field log book. Review appropriate waste management SOPs, which may be state- or client-specific.

VIII. Data Recording and Management

Fluid level measurement data will be recorded legibly on "write-in-the-rain" field notebook in indelible pen and/or a PDA. Field situations such as apparent well damage or suspected tampering, or other observations of conditions that may result in compromised data collection will be photographically documented where practicable.

IX. Quality Assurance

As described in the detailed procedure, the electronic water-level meter and/or NAPL-water interface probe will be calibrated prior to use versus an engineer's rule to ensure accurate length demarcations on the tape or cable. Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.

X. References

No literature references are required for this SOP.

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Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Rev. #: 3

Rev Date: March 9, 2009

Approval Signatures

Prepared by: David A. Lipson Date: 3/9/2009

Reviewed by: Michael J. Hefell Date: 3/9/2009
(Technical Expert)

I. Scope and Application

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and collect groundwater samples. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (USEPA SOP No. GW0001; July 30, 1996). Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. No wells will be sampled until well development has been performed in accordance with the procedures presented in the SOP titled Monitoring Well Development, unless that well has been sampled or developed within the prior 1-year time period. Groundwater samples will not be collected within 1 week following well development.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. ARCADIS personnel providing assistance to groundwater sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology.

The supervisor of the groundwater sampling team will have at least 1 year of previous supervised groundwater sampling experience.

Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, QAPP, HASP, and historical information. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

III. Equipment List

Specific to this activity, the following materials (or equivalent) will be available:

- Health and safety equipment (as required in the site Health and Safety Plan [HASP]).

- Site Plan, well construction records, prior groundwater sampling records (if available).
- Sampling pump, which may consist of one or more of the following:
  - submersible pump (e.g., Grundfos Redi-Flo 2);
  - peristaltic pump (e.g., ISCO Model 150); and/or
  - bladder pump (e.g., Marschalk System 1, QED Well Wizard, etc.).
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery.
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders).
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used. For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will also be used through the pump apparatus.
- Water-level probe (e.g., Solinist Model 101).
- Water-quality (temperature/pH/specific conductivity/ORP/turbidity/dissolved oxygen) meter and flow-through measurement cell. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument;
  - Hydrolab Series 3 or Series 4a Multiprobe and Display; and/or
  - Horiba U-10 or U-22 Water Quality Monitoring System.
- Supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020). Turbidity measurements collected with multi-parameter meters have been shown to sometimes be unreliable due to fouling of the optic lens of the

turbidity meter within the flow-through cell. A supplemental turbidity meter will be used to verify turbidity data during purging if such fouling is suspected. Note that industry improvements may eliminate the need for these supplemental measurements in the future.

- Appropriate water sample containers (supplied by the laboratory).
- Appropriate blanks (trip blank supplied by the laboratory).
- 0.45-micron disposable filters (if field filtering is required).
- Large glass mixing container (if sampling with a bailer).
- Teflon® stirring rod (if sampling with a bailer).
- Cleaning equipment.
- Groundwater sampling log (attached) or bound field logbook.

Note that in the future, the client may acquire different makes/models of some of this equipment if the listed makes/models are no longer available, or as a result of general upgrades or additional equipment acquisitions. In the event that the client uses a different make/model of the equipment listed, the client will use an equivalent type of equipment (e.g., pumps, flow-through analytical cells) and note the specific make/model of the equipment used during a sampling event on the groundwater sampling log. In addition, should the client desire to change to a markedly different sampling methodology (e.g., discrete interval samplers, passive diffusion bags, or a yet to be developed technique), the client will submit a proposed SOP for the new methodology for USEPA approval prior to implementing such a change.

The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers. Also watch for fire ant mounds near well pads when sampling in the south or western U.S.

VI. Procedure

Groundwater will be purged from the wells using an appropriate pump. Peristaltic pumps will initially be used to purge and sample all wells when applicable. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet), submersible pumps or bladder pumps will be used provided the well is constructed with a casing diameter greater than or equal to 2 inches (the minimum well diameter capable of accommodating such pumps). Bladder pumps are preferred over peristaltic and submersible pumps if sampling of VOCs is required to prevent volatilization. For

smaller diameter wells where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Purge water will be collected and containerized.

1. Calibrate field instruments according to manufacturer procedures for calibration.

2. Measure initial depth to groundwater prior to placement of pumps.

3. Prepare and install pump in well: For submersible and non-dedicated bladder pumps, decontaminate pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new Teflon® bladder and attachment of an air line, sample discharge line, and safety cable prior to placement in the well. Attach the air line tubing to the air port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Care should be taken not to reverse the air and discharge tubing lines during bladder pump set-up as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of bladder pump (if present, depending on pump model used). Slowly lower pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

4. Connect the pump to other equipment. If using a bladder pump, the discharge water line should be connected to the bottom inlet port on the flow-through cell connected to the water quality meter. Connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller if an on/off switch

is present and verify that all batteries are charged and fully operating before beginning to pump.

5. Measure the water level again with the pump in the well before starting the pump. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified). The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement) and the water level should stabilize. The water level should be monitored every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping if the well diameter is of sufficient size to allow such monitoring. Care should be taken not to break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to water. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

   If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

   During purging, monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, pH, etc.) every 3 to 5 minutes (or as appropriate). Field indicator parameters will be measured using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain within 3%, and pH remains within 0.1 units for three consecutive readings collected at 3- to 5-minute intervals (or

other appropriate interval, alternate stabilization goals may exist in different geographic regions, consult the site-specific Work Plan for stabilization criteria). If the field indicator parameters do not stabilize within 1 hour of the start of purging, but the groundwater turbidity is below the goal of 50 NTU and the values for all other parameters are within 10%, the well can be sampled. If the parameters have stabilized but the turbidity is not in the range of the 50 NTU goal, the pump flow rate should be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. If dissolved oxygen values are not within acceptable range for the temperature of groundwater (Attachment 1), then check for and remove air bubbles on probe or in tubing. If the dissolved oxygen value is 0.00 or less, then the meter should be serviced and re-calibrated.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

6. Complete the sample label and cover the label with clear packing tape to secure the label onto the container.

7. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the site-specific Work Plan).

8. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container. When the container is full, tightly screw on the cap.

9. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

10. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Attachment 2 – Example Sampling Log).

11. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing, lines, and safety cable from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them. .

12. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.

13. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

14. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

15. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate.

16. At the end of the day, perform calibration check of field instruments.

If it is not technically feasible to use the low-flow sampling method, purging and sampling of monitoring wells may be conducted using the bailer method as outlined below:

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean sampling equipment.

4. Open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field log. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the breathing zone reading is less than 5 PID units, proceed. If the PID reading in the breathing zone is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings. For wells that are part of the regular weekly monitoring program and prior PID measurements have not resulted in a breathing zone reading above 5 PID units, PID measurements will be taken monthly.

5. Measure the depth to water and determine depth of well by examining drilling log data or by direct measurement. Calculate the volume of water in the well (in gallons) by using the length of the water column (in feet), multiplying by 0.163 for a 2-inch well or by 0.653 for a 4-inch well. For other well diameters, use the formula:

   Volume (in gallons) = • TIMES well radius (in feet) squared TIMES length of water column (in feet) TIMES 7.481 (gallons per cubic foot)

6. Measure a length of rope or twine at least 10 feet greater than the total depth of the well. Secure one end of the rope to the well casing and secure the other end to the bailer. Test the knots and make sure the rope will not loosen. Check bailers so that all parts are intact and will not be lost in the well.

7. Lower bailer into well and remove one well volume of water. Contain all water in appropriate containers.

8. Monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, and pH). Measure field indicator parameters using a clean container such as a glass beaker or sampling cups provided with the instrument. Record field indicator parameters on the groundwater sampling log.

9. Repeat Steps 7 and 8 until three or four well volumes have been removed. Examine the field indicator parameter data to determine if the parameters have stabilized. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain

within 3%, and pH remains within 0.1 units for three consecutive readings collected once per well volume removed.

10. If the field indicator parameters have not stabilized, remove a maximum of five well volumes prior to sample collection. Alternatively, five well volumes may be removed without measuring the field indicator parameters.

11. If the recharge rate of the well is very low, wells screened across the water table may be bailed dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should only be bailed down to a level slightly higher than the bentonite seal above the well screen. The well should not be bailed completely dry, to maintain the integrity of the seal. Sampling should commence as soon as the well volume has recovered sufficiently to permit sample collection.

12. Following purging, allow water level in well to recharge to a sufficient level to permit sample collection.

13. Complete the sample label and cover the label with clear packing tape to secure the label onto the container.

14. Slowly lower the bailer into the screened portion of the well and carefully retrieve a filled bailer from the well causing minimal disturbance to the water and any sediment in the well.

15. The sample collection order (as appropriate) will be as follows:

    a. VOCs;

    b TOC;

    c. SVOCs;

    d. metals and cyanide; and

    e. others.

16. When sampling for volatiles, collect water samples directly from the bailer into 40-mL vials with Teflon®-lined septa.

17. For other analytical samples, remove the cap from the large glass mixing container and slowly empty the bailer into the large glass mixing container. The sample for dissolved metals and/or filtered PCBs should either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle.

18. Continue collecting samples until the mixing container contains a sufficient volume for all laboratory samples.

19. Mix the entire sample volume with the Teflon® stirring rod and transfer the appropriate volume into the laboratory jar(s). Secure the sample jar cap(s) tightly.

20. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field using a peristaltic pump prior to preservation. Install new medical-grade silicone tubing in the pump head. Place new Teflon® tubing into the sample mixing container and attach to the intake side of pump tubing. Attach (clamp) a new 0.45-micron filter (note the filter flow direction). Turn the pump on and dispense the filtered liquid directly into the laboratory sample bottles.

21. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

22. After sample containers have been filled, remove one additional volume of groundwater. Measure the pH, temperature, turbidity, and conductivity. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the field indicator parameters.

23. Remove bailer from well, secure well, and properly dispose of PPE and disposable equipment.

24. If a bailer is to be dedicated to a well, it should be secured inside the well above the water table, if possible. Dedicated bailers should be tied to the well cap so that inadvertent loss of the bailer will not occur when the well is opened.

25. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client consistent with the procedures identified in the HASP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.
- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well).
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA Region II. 1998. *Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling.*

USEPA. 1991. Handbook Groundwater, Volume II Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

Attachment 1

Groundwater Sampling Log

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Low-Flow Groundwater Sampling Log

Project _____

Project Number _____ Site Location _____ Well ID _____

Date _____ Sampled By _____

Sampling Time _____ Recorded By _____

Weather _____ Coded Replicate No. _____

Instrument Identification

Water Quality Meter(s) _____ Serial # _____

Casing Material _____ Purge Method _____

Casing Diameter _____ Screen Interval (ft bmp) Top _____ Bottom _____

Sounded Depth (ft bmp) _____ Pump Intake Depth (ft bmp) _____

Depth to Water (ft bmp) _____ Purge Time Start _____ Finish _____

Field Parameter Measurements During Purging

Time	Minutes Elasped	Flow Rate (mL/min)	Volume Purged	Temp (°C)	pH (s.u.)	Conductivity (umhos or mS/cm) [1]	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Depth to Water (ft bmp)

Collected Sample Condition Color_____ Odor_____ Appearance_____

Parameter	Container	No.	Preservative

PID Reading _____

Comments _____

1) Circle one unit type

Attachment 2

Oxygen Solubility in Fresh Water

Temperature (degrees C)	Dissolved Oxygen (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

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Water Level Measurement

Rev. #: 1

Rev Date: March 17, 2004

Approval Signatures

Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____
(Technical Expert)

Reviewed by: _____ Date: _____
(Project Manager)

I. Scope and Application

The objective of this Standard Operating Procedure (SOP) is to describe the procedure to measure and record groundwater and surface-water elevations. Water levels may be measured using an electronic oil-water level indicator or a pressure transducer from established reference points (e.g. top of casing). Reference points will be surveyed to evaluate their elevations relative to mean sea level (msl). This SOP describes the equipment, field procedures, materials, and documentation procedures necessary to measure and record groundwater and surface-water elevations using the aforementioned equipment.

This is a standard (i.e., typically applicable) operating procedure which may be varied or changed as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. The ultimate procedure employed will be documented in the project work plans or reports. . If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with DTSC as soon as practicable and documented in the report.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following materials, as required, shall be available during water level measurements:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan
- Equipment decontamination supplies (See *Field Sampling Equipment Decontamination Procedures SOP* No. 1213199)
- Electronic oil-water level indicator
- Mini-Troll® pressure transducer

- In-Situ™ data logger
- Laptop computer with the Win-Situ software package installed
- Photoionization detector (PID) and/or organic vapor analyzer
- Non-phosphate laboratory soap (Alconox or equivalent)
- Deionized/distilled water
- 150-foot measuring tape
- Solvent (methanol/acetone) rinse
- Portable containers
- Hacksaw or
- Pliers
- Plastic sheeting
- Field logbook
- Indelible ink pen.

IV. Cautions

Water level measurements will be recorded within 24-hours of monitoring well development as recommended by CalEPA (CalEPA, 1995). However, water level measurements will be recorded within 12-hours when the aquifer is influenced by tides, river stages, bank storage, impoundments, and/or unlined ditches. Finally, aquifers stressed by intermittent pumping and aquifers recharged from confined or semi-confined aquifers may demonstrate significant water level fluctuations.

V. Health and Safety Considerations

Volatile organics present in the monitoring well head space should be measured with a photoionization detector (PID) to evaluate potential hazards and recorded in the field logbook.

Well covers and casing should be removed carefully to avoid potential contact with insects or animal nesting in the well casings.

VI. Procedure

Oil-Water Indicators

Calibration procedures and groundwater level measurement procedures for oil-water indicators are described in the sections below.

Calibration Procedures

The oil-water indicator will be tested to verify that the meter has been correctly calibrated by the manufacturer. The following steps will be used to verify the accuracy of the oil-water indicator:

1. Measure the lengths between each increment marker on the oil-water indicator with a 150-foot tape measuring tape. The first 150 feet of the oil-water indicator measuring tape will be checked for accuracy.

2. If the oil-water indicator measuring tape is inaccurate, the probe will be sent back to the manufacturer.

3. Equipment calibration will be recorded in the field logbook.

Groundwater Level Measurement Procedures

A detailed procedure for obtaining water elevations using an electronic oil-water level indicator will be as follows:

1. Identify site and monitoring well number in field notebook along with date, time, personnel and weather conditions using indelible ink.

2. Use safety equipment as specified in the Health and Safety Plan.

3. Decontaminate the oil-water level indicator with an Alconox and water scrub, a distilled water rinse, a solvent rinse, and another distilled water rinse between each well in accordance with the *Field Sampling Equipment Decontamination Procedures* SOP (No. 1213199).

4. Place clean plastic sheeting on the ground next to the well.

5. Unlock and open the monitoring well cover while standing upwind from the well.

6. Measure the volatile organics present in the monitoring well head space with a PID and record the PID reading in the field logbook.

7. Allow the water level in the well to equilibrate with atmospheric pressure for a few minutes. Locate a measuring reference point on the monitoring well casing. If one is not found, create a reference point by notching the inner casing (or outer if an inner casing is not present) with a hacksaw. All downhole measurements will be taken from the reference point. Document the creation of any new reference point or alteration of the existing reference point.

8. Measure to the nearest 0.01 foot and record the height of the inner and outer casing from reference point to ground level.

9. Slowly lower the oil-water level indicator probe until it touches the bottom of the well. Record the depth of the well. Make water level, oil-water interface, and oil level measurements as the probe is drawn back up through the water column. Double check all measurements and record depths to the nearest 0.01 foot.

10. Decontaminate the instrument with an Alconox and water scrub, a distilled water rinse, a solvent rinse, and another distilled water rinse between each well in accordance with the *Field Sampling Equipment Decontamination Procedures* SOP (No. 1213199).

11. Lock the well when all activities are completed.

Pressure Transducers

The detailed procedure for obtaining water elevations using a Mini-Troll® pressure transducer with an In-Situ™ data logger and the Win-Situ software package will be as follows:

Setup Procedures

1. Connect the Mini-Troll® to a laptop computer serial port.

2. Open the Win-Situ software package on the laptop computer.

3. Verify that the Win-Situ software recognizes the Mini-Troll®.

4. Synchronize the clock on the laptop computer with that of the Mini-Troll®.

5. Add a test to the Mini-Troll® and input the specifications of the test (e.g., frequency of data collection, start data collection).

6. Disconnect the Mini-Troll® from the laptop computer, and prepare the Mini-Troll® for field deployment.

Field Procedures

1. Decontaminate all equipment entering the monitoring well with an Alconox and water scrub, a distilled water rinse, a solvent rinse, and another distilled water rinse between each well in accordance with the *Field Sampling Equipment Decontamination Procedures* SOP (No. 1213199).

2. Connect Mini-Troll® to laptop computer, and start the Win-Situ program.

3. Lower the Mini-Troll® gently below the water table.

4. Take a water level reading from the Mini-Troll® using the Win-Situ software package.

5. Lift the Mini-Troll® approximately 1-foot, and verify the Mini-Troll® response on the Win-Situ program (i.e. depth to water should be 1-foot lower).

6. Upon verification, set the Mini-Troll® to the desired depth. Position the instrument below the lowest anticipated water level, but not so low that its range will be exceeded at the highest anticipated water level.

7. Secure the cable to prevent drift and movement.

8. Set reference point (e.g. depth to water, groundwater elevation) and input it into the Win-Situ software package.

9. Periodically download data and collect manual depth to water measurements using the same oil-water indicator probe used during the equipment setup to verify the accuracy of the Mini-Troll®.

VII. Waste Management

Decontamination water should be containerized and characterized in accordance with California Environmental Protection Agency's procedures for *Representative Sampling of Groundwater for Hazardous Substances* (CalEPA, 1995). Rinse water, personal protective equipment, and other residuals generated during equipment

decontamination will be placed in appropriate containers and labeled. Containerized waste will be disposed of consistent with appropriate procedures as outlined in the *Handling and Storage of Investigation-Derived Waste SOP* (No. 152319).

VIII. Data Recording and Management

Groundwater level measurements should be documented in the field logbook. The following information will be documented in the field logbook:

- Sample identification
- Measurement time
- Total well depth
- Depth to water
- Depth to product, if encountered
- Product thickness, if encountered.

Groundwater elevations recorded using a Mini-Troll® pressure transducer with an In-Situ™ data logger and the Win-Situ software package will be downloaded and stored in the central project file.

IX. Quality Assurance

The oil-water indicator tape may need to be weighted for deeper monitoring wells. The amount of weight added should be sufficient enough to keep the oil-water indicator tape straight. Standing water level measurement devices are not appropriate for recording the depth of monitoring wells (CalEPA, 1995).

X. References

California Environmental Protection Agency (CalEPA). 1995. *Representative Sampling of Groundwater for Hazardous Substances. Guidance Manual for Ground Water Investigations*. July 1995.

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Appendix B

Chain of Custody

APPENDIX B

ARCADIS
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Chain-of-Custody, Handling, Packing and Shipping

Rev. #: 2

Rev Date: March 6, 2009

Approval Signatures

Prepared by: _____ Date: 3/6/09
Caron Koll

Reviewed by: _____ Date: 3/6/09
Jane Kennedy(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody, handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to insure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, Department of Transportation (DOT) training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following list provides materials that may be required for each project. Project documents and sample collection requirements should be reviewed prior to initiating field operations:

- indelible ink pens (black or blue);
- polyethylene bags (resealable-type);
- clear packing tape, strapping tape, duct tape;
- chain of custody
- DOT shipping forms, as applicable
- custody seals or tape;
- appropriate sample containers and labels,;
- insulated coolers of adequate size for samples and sufficient ice to maintain 4°C during collection and transfer of samples;
- wet ice;
- cushioning and absorbent material (i.e., bubble wrap or bags);

- temperature blank
- sample return shipping papers and addresses; and
- field notebook.

IV. Cautions

Review project requirements and select appropriate supplies prior to field mobilization.

Insure that appropriate sample containers with applicable preservatives, coolers, and packing material have been supplied by the laboratory.

Understand the offsite transfer requirements for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation. Prior to using air transportation, confirm air shipment is acceptable under DOT and International Air Transport Association (IATA) regulation

Schedule pick-up time for laboratory courier or know location of laboratory/service center and hours of operation.

Understand DOT and IATA shipping requirements and evaluate dangerous goods shipping regulations relative to the samples being collected (i.e. complete an ARCADIS shipping determination). Review the ARCADIS SOPs for shipping, packaging and labeling of dangerous goods. Potential samples requiring compliance with this DOT regulation include:

- Methanol preservation for Volatile Organic Compounds in soil samples
- Non-aqueous phase liquids (NAPL)

V. Health and Safety Considerations

Follow health and safety procedures outlined in the project/site Health and Safety Plan (HASP).

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

Some sample containers contain preservatives.

- The preservatives must be retained in the sample container and should in no instance be rinsed out.
- Preservatives may be corrosive and standard care should be exercised to reduce potential contact to personnel skin or clothing. Follow project safety procedures if spillage is observed.
- If sample container caps are broken discard the bottle. Do not use for sample collection.

VI. Procedure

Chain-of-Custody Procedures

1. Prior to collecting samples, complete the chain-of-custody record header information by filling in the project number, project name, and the name(s) of the sampling technician(s) and other relevant project information. Attachment 1 provides an example chain-o- custody record

2. Chain-of-custody information MUST be printed legibly using indelible ink (black or blue).

3. After sample collection, enter the individual sample information on the chain-of-custody:

    a. Sample Identification indicates the well number or soil location that the sample was collected from. Appropriate values for this field include well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be "SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain-of-custody form. DO NOT use the apostrophe or quotes in the sample ID. Sample names may also use the abbreviations "FB," "TB," and "DUP" as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively. NOTE: The sample

nomenclature may be dictated by the project database and require unique identification for each sample collected for the project. Consult the project data management plan for additional information regarding sample identification.

b. List the date o sample collection. The date format to be followed should be mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

c. List the time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. The composite field should be checked if the sample is a composite over a period of time or from several different locations and mixed prior to placing in sample containers.

e. The "Grab". field should be marked with an "X" if the sample was collected as an individual grab sample. (e.g. monitoring well sample or soil interval).

f. Any sample preservation should be noted.

g. The analytical parameters that the samples are being analyzed for should be written legibly on the diagonal lines. As much detail as possible should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering "PCBs" or "Method 8082." Multiple methods and/or analytical parameters may be combined for each column (e.g., PCBs/VOCs/SVOCs or 8082/8260/8270). These columns should also be used to present project-specific parameter lists (e.g., Appendix IX+3 target analyte list. Each sample that requires a particular parameter analysis will be identified by placing the number of containers in the appropriate analytical parameter column. For metals in particular, indicate which metals are required.

h. Number of containers for each method requested. This information may be included under the parameter or as a total for the sample based on the chain of custody form used.

i. Note which samples should be used for site specific matrix spikes.

j. Indicate any special project requirements.

k. Indicate turnaround time required.

l. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory.

m. If available attach the Laboratory Task Order or Work Authorization forms

n. The remarks field should be used to communicate special analytical requirements to the laboratory. These requirements may be on a per sample basis such as "extract and hold sample until notified," or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG). Reporting requirements that should be specified in the remarks column include: 1) turnaround time; 2) contact and address where data reports should be sent; 3) name of laboratory project manager; and 4) type of sample preservation used.

o. The "Relinquished By" field should contain the signature of the sampling technician who relinquished custody of the samples to the shipping courier or the analytical laboratory.

p. The "Date" field following the signature block indicates the date the samples were relinquished. The date format should be mm/dd/yyyy (e.g., 03/07/2005).

q. The "Time" field following the signature block indicates the time that the samples were relinquished. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

r. The "Received By" section is signed by sample courier or laboratory representative who received the samples from the sampling technician or it is signed upon laboratory receipt from the overnight courier service.

3. Complete as many chain-of-custody forms as necessary to properly document the collection and transfer of the samples to the analytical laboratory.

4. Upon completing the chain-of-custody forms, forward two copies to the analytical laboratory and retain one copy for the field records.

5. If electronic chain-of-custody forms are utilized, sign the form and make 1 copy for ARCADIS internal records and forward the original with the samples to the laboratory.

Handling Procedures

1. After completing the sample collection procedures, record the following information in the field notebook with indelible ink:

   - project number and site name;
   - sample identification code and other sample identification information, if appropriate;
   - sampling method;
   - date;
   - name of sampler(s);
   - time;
   - location (project reference);
   - location of field duplicates and both sample identifications;
   - locations that field QC samples were collected including equipment blanks, field blanks and additional sample volume for matrix spikes; and
   - any comments.

2. Complete the sample label with the following information in indelible ink:

   - sample type (e.g., surface water);
   - sample identification code and other sample identification information, if applicable;
   - analysis required;
   - date;
   - time sampled; and
   - initials of sampling personnel;

- sample matrix; and
- preservative added, if applicable.

3. Cover the label with clear packing tape to secure the label onto the container and to protect the label from liquid.

4. Confirm that all caps on the sample containers are secure and tightly closed.

5. In some instances it may be necessary to wrap the sample container cap with clear packing tape to prevent it from becoming loose.

6. For some projects individual custody seals may be required. Custody seal evidence tape may be placed on the shipping container or they may be placed on each sample container such that the cooler or cap cannot be opened without breaking the custody seal. The custody seal should be initialed and dated prior to relinquishing the samples.

Packing Procedures

Following collection, samples must be placed on wet ice to initiate cooling to 4°C immediately. Retain samples on ice until ready to pack for shipment to the laboratory.

1. Secure the outside and inside of the drain plug at the bottom of the cooler being used for sample transport with "Duct" tape.

2. Place a new large heavy duty plastic garbage bag inside each cooler

3. Place each sample bottle wrapped in bubble wrap inside the garbage bag. VOC vials may be grouped by sample in individual resealable plastic bags). If a cooler temperature blank is supplied by the laboratory, it should be packaged following the same procedures as the samples. If the laboratory did not include a temperature blank, do not add one. Place 1 to 2 inches of cushioning material (i.e., vermiculite) at the bottom of the cooler.

4. Place the sealed sample containers upright in the cooler.

5. Package ice in large resealable plastic bags and place inside the large garbage bag in the cooler. Samples placed on ice will be cooled to and maintained at a temperature of approximately 4°C.

6. Fill the remaining space in the cooler with cushioning material such as bubble wrap. The cooler must be securely packed and cushioned in an upright position and be surrounded (Note: to comply with 49 CFR 173.4, filled cooler must not exceed 64 pounds).

7. Place the completed chain-of-custody record(s) in a large resealable bag and tape the bag to the inside of the cooler lid.

8. Close the lid of the cooler and fasten with packing tape.

9. Wrap strapping tape around both ends of the cooler.

10. Mark the cooler on the outside with the following information: shipping address, return address, "Fragile, Handle with Care" labels on the top and on one side, and arrows indicating "This Side Up" on two adjacent sides.

11. Place custody seal evidence tape over front right and back left of the cooler lid, initial and date, then cover with clear plastic tape.

Note: Procedure numbers 2, 3, 5, and 6 may be modified in cases where laboratories provide customized shipping coolers. These cooler types are designed so the sample bottles and ice packs fit snugly within preformed styrofoam cushioning and insulating packing material.

Shipping Procedures

1. All samples will be delivered by an express carrier within 48 hours of sample collection. Alternatively, samples may be delivered directly to the laboratory or laboratory service center or a laboratory courier may be used for sample pickup.

2. If parameters with short holding times are required (e.g., VOCs [EnCore™ Sampler], nitrate, nitrite, ortho-phosphate and BOD), sampling personnel will take precautions to ship or deliver samples to the laboratory so that the holding times will not be exceeded.

3. Samples must be maintained at 4°C+2°C until shipment and through receipt at the laboratory

4. All shipments must be in accordance with DOT regulations and ARCADIS dangerous goods shipping SOPs.

5. When the samples are received by the laboratory, laboratory personnel will complete the chain-of-custody by recording the date and time of receipt of samples, measuring and recording the internal temperature of the shipping container, and checking the sample identification numbers on the containers to ensure they correspond with the chain-of-custody forms.

Any deviations between the chain-of-custody and the sample containers, broken containers, or temperature excursions will be communicated to ARCADIS immediately by the laboratory.

VII. Waste Management

Not applicable

VIII. Data Recording and Management

Chain-of-custody records will be transmitted to the ARCADIS PM or designee at the end of each day unless otherwise directed by the ARCADIS PM. The sampling team leader retains copies of the chain-of-custody forms for filing in . the project file. Record retention shall be in accordance with project requirements.

IX. Quality Assurance

Chain-of-custody forms will be legibly completed in accordance with the applicable project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents. A copy of the completed chain-of-custody form will be sent to the ARCADIS Project Manager or designee for review.

X. References

Not Applicable

Attachment 1

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ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:

Contact & Company Name: | Telephone:

Address: | Fax:

City: State: Zip: | E-mail Address:

Project Name/Location (City, State): | Project #:

Sampler's Printed Name: | Sampler's Signature:

Sample ID	Collection Date	Collection Time	Type (✓) Comp.	Type (✓) Grab	Matrix

Preservative								
Filtered (✓)								
# of Containers								
Container Information								

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCl
C. HNO_3
D. NaOH
E. None
F. Other _____
G. Other _____
H. Other _____

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other _____
10. Other _____

Matrix Key:
SO - Soil | SE - Sediment | NL - NAPL/Oil
W - Water | SL - Sludge | SW - Sample Wipe
T - Tissue | A - Air | Other: _____

REMARKS

Special Instructions/Comments:

☐ Special QA/QC Instructions(✓):

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #	Condition/Cooler Temp: _____	Date/Time:	Date/Time:	Date/Time:	Date/Time:

20730826 CofC AK Form 01.12.2007

Distribution: **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by BBL**

APPENDIX C

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Appendix C

Laboratory Standard Operating Procedures and Quality Assurance

Trace Analytical Laboratories, Inc. and Pace Analytical Services, Inc.

(On CD-ROM)

APPENDIX D

ARCADIS

Appendix D

MDNRE Operational Memorandum No. 2 and USEPA Low Stress Purging and Sampling Procedure

ARCADIS

Appendix D-1

MDNRE Operational
Memorandum No. 2, Attachment 5
Collection of Samples for
Comparison to Generic Criteria

October 22, 2004

RRD OPERATIONAL MEMORANDUM NO. 2

SUBJECT: SAMPLING AND ANALYSIS - ATTACHMENT 5
COLLECTION OF SAMPLES FOR COMPARISON TO GENERIC CRITERIA

Key definitions for terms used in this document:

NREPA:	The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
Part 201:	Part 201, Environmental Remediation, of NREPA
Part 211:	Part 211, Underground Storage Tank Regulations, of NREPA
Part 213:	Part 213, Leaking Underground Storage Tanks, of NREPA
MDEQ:	Michigan Department of Environmental Quality
RRD:	Remediation and Redevelopment Division
U.S. EPA:	United States Environmental Protection Agency
Criteria or criterion:	Includes the cleanup criteria for Part 201 and the Risk-based Screening Levels as defined in Part 213 and R 299.5706a(4)
Facility:	Includes "facility" as defined by Part 201 and "site" as defined by Part 213
Low Flow:	Minimal drawdown groundwater sampling procedures as described in the United States Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response, EPA/540/S-95/504, December, 1995, EPA Groundwater Issue
Response Actions:	Includes "response activities" as defined by Part 201 and "corrective action" as defined by Part 213

PURPOSE

This attachment to RRD Operational Memorandum No. 2 provides direction for collection of groundwater and soil samples for comparison to generic criteria for site assessment, site investigation, and response actions under Part 201, Part 211, and Part 213.

Generic cleanup criteria for groundwater and soil have been developed pursuant to Sections 20120a(1) and 21304a of NREPA (see RRD Operational Memorandum No. 1). These criteria are the risk-based values the department has determined to be protective of the public health, safety, or welfare and the environment. The evaluation of sampling data to establish compliance with cleanup criteria under the provisions of Part 201, Part 211, and Part 213 requires data that reliably establish a representative concentration of the hazardous substance in a given environmental medium. The representativeness of the data can be maximized by using proven accurate and reproducible techniques and verified by using appropriate quality assurance and control procedures in the field and laboratory. This operational memorandum designates sampling, analysis, and quality assurance and control protocols for consistent data collection to facilitate gathering the information necessary for the department to determine compliance with the applicable provisions of Part 201, Part 211, or Part 213. Additional guidance regarding sampling strategies and methodology is available in RRD Operational Memorandum No. 4.

CALIBRATION OF FIELD EQUIPMENT

Instruments and equipment used to gather, generate, or measure environmental data should be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Equipment used for field sampling should be examined to certify that it is in operating condition. This includes checking the manufacturing's operating manual and the instructions for each instrument to ensure that all maintenance requirements are being observed. Calibration of field instruments should be performed in accordance with the manufacturer's recommendations and guidelines and at the intervals specified by the manufacturer or more frequently as conditions dictate. At a minimum, equipment should be calibrated prior to each sampling event. In the event that an internally calibrated field instrument fails to meet calibration/checkout procedures, it should not be used in the field until it is serviced and calibrated.

COLLECTION OF SOIL SAMPLES FOR COMPARISON TO THE GENERIC CRITERIA

General Considerations

The soil and groundwater terminology used for this discussion include the following:

- Unsaturated/Vadose Zone: a subsurface zone above the capillary fringe in which the soil pores are only partially filled with water. The moisture content is less than the porosity.
- Saturated Zone: contains two components
    - Capillary Fringe: a subsurface zone above the water table in which the soil pores are filled with water and the pressure heads are less than atmospheric.
    - Water Table: the water level surface below the ground at which a well screened in an unconfined aquifer would fill with water.
- Smear Zone: the vertical area over which groundwater fluctuates (thereby the contaminated water will smear floating and dissolved contamination into the soils in the zone).

Soil samples must be representative of the soils located in the area affected by the release of hazardous substances. The exposure assumptions for soil pathways are based on dry soil. For comparison to the applicable generic soil criteria soil samples must be collected from the vadose zone. The results must be reported by the laboratory on a dry weight basis (adjusted for the vadose zone soil moisture content). Soil analytical methods cannot be applied to saturated soils because they do not provide representative results.

Neither soil nor water sample analyses methods are appropriate for comparison of saturated "soils" samples to generic soil or groundwater cleanup criteria. The cleanup criteria are based upon exposure assumptions appropriate only for soil or water, individually, and are not applicable to exposure to saturated "soil" as a mixture of soil and water.

Contaminants present in the unsaturated soil zone shall be evaluated by comparison of soil sample analyses to the applicable soil criteria. If contaminants are present in a saturated soil zone a monitoring well should be properly installed and the groundwater sampled. These groundwater sample results shall be compared to the applicable groundwater criteria. If free product is suspected and/or a smear zone exists near the water table, a monitoring well shall be appropriately installed so that the water table is bisected by the well screen. Additional

guidance regarding monitor well construction is available in RRD Operational Memorandum No. 4.

While analysis of saturated "soil" samples cannot be used to demonstrate compliance with generic cleanup criteria, laboratory analyses or field instrument readings of saturated soils may be of qualitative value for remedial evaluation and design purposes. For example indications of high concentrations in saturated soils may indicate a need to prevent construction worker exposure to shallow saturated soils. This information may also assist in determining the nature of the contaminant and in treatment evaluations. If such data are included as part of response actions under Part 201 or Part 213 rationale for the use must be provided.

If the water surface elevation drops significantly from the time that the original soil investigation was performed, samples should be collected from any former "smear zone" prior to site closure.

Evaluating Exposure Due To Lead In Soil

The amount of lead in soil has historically been evaluated by analyzing lead concentrations in the total soil sample. However, recent evidence indicates that the fine soil fraction, defined as less than 250 microns in size, is more appropriate for comparison to soil direct contact criteria (DCC) and particulate inhalation criteria (PSIC). Exposure to lead in ingested soil and dust is best represented by the lead concentration in the particle size fraction that sticks to hands or that is most likely to accumulate in the indoor environment as a result of wind-blown soil deposition and transport of soil on clothes, shoes, pets, toys and other objects. Additionally, exposure to lead in inhaled soil and dust is best represented by the lead concentration in the particle size fraction likely to enter the respiratory system and become lodged in the alveoli. The particle size fraction of soil and dust likely to be ingested or inhaled is the fine soil fraction. Generally the fine fraction has the higher concentration of lead, but it is possible that the coarse fraction may contain more lead. Therefore, when collecting soils for facility evaluation, both fine and coarse fraction analyses are necessary to determine lead exposure. MDEQ Laboratory SOP #213 provides appropriate procedures for sample preparation. To assure protectiveness, the concentration of lead in each fraction must be compared to the direct contact criteria separately. Only the concentration of lead in the fine fraction must be compared to particulate soil inhalation criteria. The concentration the total lead concentration must be compared to other lead soil criteria. For response actions under Part 201 and Part 213, if the direct contact and particulate inhalation pathways have been appropriately documented to be "not relevant" it is not necessary to analyze the fractions separately.

COLLECTION OF GROUNDWATER SAMPLES FOR COMPARISON TO THE GENERIC CRITERIA

General Considerations

Groundwater samples collected for analyses must be representative of the water moving in the aquifer, in the contaminant plume or in the target zone where contaminants are expected to be located or to migrate. Groundwater samples must represent the contaminant concentrations, including dissolved and naturally suspended particles. Stagnant water in monitor well casings is not representative of the groundwater. Purging of the stagnant water in monitor well casings is necessary but must minimize changes in groundwater chemistry to yield water samples that are representative of the groundwater. Indicator parameters including temperature, pH, dissolved oxygen, specific conductivity and turbidity must be monitored during the purging process to determine stabilization between the well casing waters and the formation waters. Turbidity is the most conservative indicator of stabilization as it is often the last to stabilize. Turbidity in

groundwater samples may be naturally occurring, caused by the contamination, or a result of sampling disturbances such as accidental inclusion of aquifer matrix materials from disturbances or mixing that may occur while sampling. Knowledge of site geology, well design, and sampling methodology is helpful in determining the source of turbidity and the method of sampling. Turbidity due to sampling disturbances should be eliminated or minimized while naturally occurring turbidity or turbidity due to contamination should not.

A sampling methodology must be used that accounts for the effects of aquifer heterogeneities while minimizing alterations in water chemistry that could result from sampling disturbances. The MDEQ will accept properly conducted purging methods designed to minimize drawdown by controlling the flow from the well while monitoring stabilization indicator parameters, commonly referred to as Low-Flow methods. Available Low-Flow procedures include United States Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response, EPA/540/S-95/504, December 1995, EPA Ground Water Issue, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, Robert Puls and Michael Barcelona (http://www.solinst.com/Text/restext/407txt.html) and *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*, United States Environmental Protection Agency Region 1, July 30, 1996, Revision 2 (http://www.epa.gov/region01/measure/well/wellmon.html). If another sampling methodology is used, documentation must be submitted to the MDEQ with the data that demonstrates why it is as representative of aquifer conditions as low-flow methodologies. Careful use of the Low-Flow methods is essential in collection of groundwater samples from wells that contain non-aqueous phase liquids, as these substances may be stratified in the monitoring well. Where non-aqueous phase liquid is present, refer to additional guidance for sampling strategies for non-aqueous phase liquids available in RRD Operational Memorandum No. 4, Attachment 5.

Collection of Inorganic Groundwater Samples

Traditionally, the standard practice for collecting metals samples from monitoring wells to evaluate the drinking water pathway had prescribed that samples be filtered with a 0.45 micron filter before inorganic analysis. The practice minimizes the potential for artificially elevated particulate loading resulting in overestimation of metal concentrations. However, U.S. EPA has determined that contaminant concentrations and the potential human health risk may be drastically underestimated for filtered samples (*Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*, U.S. EPA Region 1, July 30, 1996, Rev 2). Use of the Low-Flow sampling methodologies minimizes sampling disturbances, improves the data quality, and is the method recommended by the MDEQ.

Inorganic constituents must be measured as totals (i.e., unfiltered with appropriate preservation) unless groundwater samples cannot be collected without adequately minimizing the influence of sampling disturbances, in which case filtering may be necessary prior to preservation. The intent of the field-filtration is only to eliminate or minimize sampling disturbances or interference. Any necessary filtration should be accomplished using a filter with a large enough pore size to allow naturally suspended particles to pass through the filter. Some preliminary testing may be required to determine the appropriate filter size. Site-specific conditions may require that both a filtered and unfiltered sample be collected to adequately evaluate the contaminant concentrations. Documentation for the use of filtration and the evaluation of appropriate filter sizes must be provided to the MDEQ with the data.

Collection of Organic Groundwater Samples

Samples to be analyzed for organic substances should not be filtered regardless of sample turbidity except as described in the next paragraph. When response action under Part 201 or Part 213 requires evaluation of the dermal contact with groundwater for contaminants listed in R 299.5750 footnote (AA) an additional set of groundwater samples should be collected for organic substances analysis which should be filtered for analysis of the dissolved phase. The groundwater contact criteria equation estimates the dermal adsorption of hazardous substances that are in the dissolved phase. Therefore, when analyzing for contaminants that strongly adsorb to soil particles, those samples should be filtered so that contaminants in the dissolved phase can be estimated. Filters of appropriate material should be used to ensure the filter does not absorb dissolved contaminants that are not attached to particulates. Glass filters with no binders are acceptable and recommended. Some preliminary testing may be required to determine the appropriate filter medium and pore size. Documentation of the evaluation of appropriate filter medium and size must be provided to the MDEQ with the data.

GENERAL QUALITY ASSURANCE AND QUALITY CONTROL

In order to insure that representative data is used to evaluate facilities, quality assurance and quality control (QA/QC) procedures must be implemented to assure that the precision, accuracy, and representativeness of the data are known and documented. This includes appropriate sample distribution to evaluate the extent of contamination; appropriate sample collection, preservation, shipping, and analysis methodology; collection and analysis of collocated, replicate and split duplicate samples for evaluation of precision; and collection and analysis of field, equipment, and trip blanks as well as matrix spike, matrix spike/duplicate, and laboratory spike samples for analysis of accuracy. Sample distribution and collection are more completely discussed in Operational Memorandum No. 4. Sample handling, preservation, and holding times are discussed in Attachment 4 of this Operational Memorandum. Collection of duplicate, blank and spike samples is discussed below.

Collection of Duplicate Samples to Evaluate Precision

Precision estimates the reproducibility of measurements under a given set of conditions and is reflected in the field duplicate samples and laboratory duplicates analysis. Overall precision for a sampling set is a mixture of field sampling techniques and laboratory techniques. Three types of duplicate samples are relevant to this document: collocated, replicates, and split samples. Collocated samples should be collected and used to estimate the overall precision of a data collection activity. Sampling error can be estimated by inclusion of both collocated and replicated versions of the same samples. Definitions of these samples are listed below:

- Collocated samples are independent samples collected at the same location and at the same time and, for the purpose of these site assessments, processed and analyzed by the same laboratory. Collocated samples are not mixed together and then split into two or more samples. They are two separate samples from an identical site location. They provide a good estimate of precision information for the entire system, including transportation, sampling technique, homogeneity of the site, and laboratory analysis. Examples of collocated samples are samples taken from a moving stream, side by side soil core samples (nesting), two air quality samples taken from one common sample manifold, and two water samples taken from essentially the same point in a lake or lagoon. Collocated samples are used to estimate the

overall precision of a data collection activity. Sampling error can be estimated by including a replicate sample with a collocated sample.

- Replicate samples are samples that have been divided into two or more portions at the same step in the measurement process. Examples of replicate samples include two samples taken from a single purged well, samples collected in a common container and then put into separate containers or a soil sample which is thoroughly mixed in a tray and divided into separate containers. Replicate samples are processed and analyzed by the same laboratory.
- Split samples are replicate samples divided into two portions, sent to different laboratories, and subjected to the same environmental conditions and steps in measurement process. They serve as an oversight function in assessing the analytical portion of a measurement system. Samples are often split between the MDEQ and a facility owner or liable party.

Collection of Blank and Spike Samples to Evaluate Accuracy

Accuracy estimates the bias in a measurement system. Accuracy is difficult to estimate for the entire data collection activity. Sources of error include: sampling procedure; field contamination; preservation handling; sample matrix; sample preparation; and analytical techniques. Sampling accuracy can be audited through field, equipment, and trip blanks, while analytical (or laboratory) accuracy can be audited through spike samples and the surrogate recovery results.

A field blank is prepared by pouring distilled/deionized water directly into sample containers. This preparation is performed in the area where sample handling and preservation operations occur. The field blank sample is handled and shipped in the same manner as other analytical samples. Field blank sample analytical results are used to evaluate sample handling, preservation, and shipping procedures.

An equipment blank can be prepared by pouring distilled/deionized water through or over a piece of sampling equipment and collecting rinsate in a sample container. Results of equipment blank analysis are used to evaluate field decontamination procedures and to determine the likelihood of cross contamination.

A trip blank, which normally applies only to volatiles, is a sample that is prepared before any sampling is performed. This sample is shipped from the warehouse to the field and then to the laboratory. Results of trip blank analysis are used to evaluate possible contamination of containers/samples from the time the sample containers are prepared through the field event to the time the samples are received and analyzed at the laboratory.

Laboratory blanks are used to estimate variabilities caused by technique, in-house contamination, and other laboratory problems. Laboratory blanks are prepared by the laboratory.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples and surrogates are samples that are spiked in the laboratory. MS/MSD samples for organic and inorganic water analyses require an extra sample volume. The actual MS/MSD sample is prepared by the laboratory to evaluate accuracy.

Field background, or upgradient samples may need to be collected on a site-specific basis and should be collected from a clean location and shipped with other samples from the site. These samples should be submitted to the laboratory as routine field samples and should not be defined as blanks.

To provide adequate QA/QC for site investigations, the following duplicate, blank and matrix spike samples should be taken. Duplicate and field blank samples should be taken at critical sampling locations, but not at the same location from which the matrix spike/duplicate sample is obtained. They should be sent to the laboratory as blind samples. Reduced QA/QC evaluations may be implemented on a case by case basis with approval of the MDEQ RRD Project Manager.

	Duplicate Samples[1]				Blank Samples		
QA/QC Sample Type	**Collocated**	**Replicate**	**Split**	**MS/MSD**	**Field**	**Equipment**	**Trip**
Recommended Number of QA/QC Samples	1 per 10 or fewer samples per matrix[2] and analytical group[3], at least 1 per day	When used: 1 per matrix and analytical group per day	When used: 1 per 1 for samples that will be split	1 per 20 or fewer samples per matrix and analytical group, at least 1 per day	1 per 20 or fewer samples per matrix and analytical group, at least 1 per day	1 per 10 or fewer samples per matrix and analytical group, at least 1 per day	1 per every volatile organic sample shipping container
QA/QC Sample Collection	Individual samples taken from the same location not mixed together and then split.	One sample divided into two or more portions then analyzed by the same laboratory	Replicate samples sent to different labs for analysis	Water samples require double volumes. Samples should be taken at critical locations but different from the field blank.	Fill the sample containers with deionized or distilled water in the area where sample handling and preserving operations occur. Handle and ship the field blank sample as other samples.	Pour deionized or distilled water over or through the sampling equipment and collect rinsate in the sample container. Handle and ship the field blank sample as other samples.	Fill the sample container with deionized water. This in prepared before any sampling is performed and travels to the field and the laboratory with the other sample containers.

[1] Normally no field duplicate is required for samples of waste containers or other high concentration samples.

[2] soil, groundwater, surface water, sediment, or drinking water, etc.

[3] volatile organics, semi-volatiles. pesticides/PCBs, metals, cyanide, etc.

Note: Where method 8260+ volatile analysis for soils, sediments, sludges, and waste container samples is done, methanol blank samples should be collected by the laboratory for each methanol lot used. These lots should be tracked in the field and reported on the laboratory receipt form so laboratory correlations can be made.

SAMPLE CHAIN OF CUSTODY

An essential part of any sampling and analytical scheme is ensuring the integrity of the sample from collection to data reporting. The possession and handling of samples should be traceable from the time of collection through analysis and final disposition. This documentation, referred to as chain of custody, is particularly necessary if there is any possibility that the analytical data or conclusions based upon analytical data will be used in litigation. Regardless of the potential for litigation, these procedures are useful for routine control of sample flow.

A sample is under your custody if it is in your possession; is in your view, after being in your possession; was in your possession and you placed them in a secured location; or is in a designated secure area.

As few people as possible should handle the samples. The field sampler/sampling crew should track the chain of custody in the field on the individual sample data collection sheets and chain of custody tracking reports before shipment. Samples should be collected following the appropriate sampling procedures and documented on the sample data sheet. The equipment used to collect samples should be noted, along with the time of sampling, sample location, type and description, depth at which the sample was collected, and any other pertinent remarks. All bottles and jars should be properly labeled with sample number, date and time of collection, and location. Sample labels and tags should be affixed to the each sample container prior to or at the time of sampling. Sample seals should be used to detect any unauthorized tampering with samples from the time of sample collection to the time of analysis.

A record should be kept of data-collecting activities performed. A field logbook is a useful tool for keeping such records. Entries into the logbook may contain a variety of information such as site contacts, phone numbers, assigned laboratories, addresses, etc. Documentation of on site weather conditions and activities that take place during sampling events should be described in as much detail as possible so that persons going to the site can re-construct a particular situation without reliance on memory. The record for each sampling event should include the date, start time, names of all persons present, level of personal protection being used, and the signature of the person recording the information. Measurements made and samples collected should be recorded. All entries in field logbooks should be made in ink and no erasures made. If an incorrect entry is made, the information should be crossed out with a single strike mark. When a sample is collected, or a measurement is made, a detailed description of the location of sample collection (such as a map point which includes compass and distance measurements or Global Positioning System location information) should be recorded. Equipment used to make measurements should be identified, along with the date of calibration.

A chain of custody record should be filled out and should accompany every sample container shipped or delivered to the laboratory. This record becomes especially important if the sample data could be introduced as evidence in litigation. For each sample in the container, the chain of custody record should include the sample number, signature of the collector, date and time of collection, place and address of collection, sample matrix, and signature and inclusive dates of possession for each person involved in the chain of possession from the point of sample collection through sample analysis.

The following document is rescinded with the issuance of this attachment:

- Storage Tank Division Informational Memorandum 16, Policy regarding the appropriate use of saturated soil sampling results under the Leaking Underground Storage Tank (LUST) Program, dated October 21, 1998.

This memorandum and its attachments are intended to provide direction and guidance to foster consistent application of Part 201, Part 211, and Part 213 and the associated administrative rules. This document is not intended to convey any rights to any parties or create any duties or responsibilities under the law. This document and matters addressed herein are subject to revision.

ARCADIS

Appendix D-2

MDNRE Operational
Memorandum No. 2, Attachment 7
Low Level Mercury Sampling
Specifications

October 22, 2004

RRD OPERATIONAL MEMORANDUM NO. 2

SUBJECT: SAMPLING AND ANALYSIS - ATTACHMENT 7
LOW LEVEL MERCURY SAMPLING SPECIFICATIONS

Key definitions for terms used in this document:

NREPA:	The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
Part 201:	Part 201, Environmental Remediation, of NREPA
Part 211:	Part 211, Underground Storage Tank Regulations, of NREPA
Part 213:	Part 213, Leaking Underground Storage Tanks, of NREPA
MDEQ:	Michigan Department of Environmental Quality
RRD:	Remediation and Redevelopment Division
U.S. EPA:	United States Environmental Protection Agency
Criteria or criterion:	Includes the cleanup criteria for Part 201 and the Risk-based Screening Levels as defined in Part 213 and R 299.5706a(4)
Facility:	Includes "facility" as defined by Part 201 and "site" as defined by Part 213

PURPOSE

This attachment to RRD Operational Memorandum No. 2 provides guidance for the collection of groundwater samples from monitoring wells for analysis using U.S. EPA Method 1631, Revision B; Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry, U.S. EPA, Office of Water, EPA-821-R-99-005, May 1999, to evaluate mercury concentrations in groundwater venting to surface water and determine compliance with the groundwater to surface water interface (GSI) criterion. The GSI criterion is based on "total" mercury, i.e., all forms of mercury existing in the groundwater. This includes both inorganic and organic types, dissolved or attached to particulate present in the groundwater.

This attachment is applicable to site investigation and response activities under Part 201, and Part 213 of NREPA.

SUMMARY

The U.S. EPA Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Criteria Levels, July 1996, U.S. EPA, Office of Water, Engineering and Analysis Division, Washington D.C., was used as a reference to develop this attachment. The two-person team approach, as described in Method 1669, "Dirty Hands," and "Clean Hands" sampling was adopted, and quality assurance and control requirements of that method have been incorporated.

Modifications of this method, and other methods, may be proposed and used if found adequate by the MDEQ to produce reliable results for sampling groundwaters for low level mercury. The presentations of information that validate the use of other methods or modifications of this method are the responsibility of the parties proposing their use. This attachment is not intended to be used in place of Method 1669 when the use of that method is required.

CONTACTS

Information regarding this operational memorandum attachment may be directed to:

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Sandra Gregg: Lab Analysis: 517-335-9800; greggs@michigan.gov.

The following documents are rescinded with the issuance of this attachment:

- Environmental Response Division Procedure, "Groundwater Sampling from Monitoring Wells for Low Level Analysis of Mercury" dated April 13, 2001.

APPENDAGE:

Low Level Mercury Sampling and Analysis Specification

This memorandum and its attachment are intended to provide direction and guidance to foster consistent application of Part 201, Part 211, and Part 213 and the associated administrative rules. This document is not intended to convey any rights to any parties or create any duties or responsibilities under the law. This document and matters addressed herein are subject to revision.

LOW LEVEL MERCURY SAMPLING AND ANALYSIS SPECIFICATIONS

Summary

Sampling equipment, materials, and containers are cleaned using high purity chemicals and double bagged for protection from contamination during storage and transportation. Highly purified reagent water is provided to the field personnel for the decontamination of the equipment and collection of field blanks. High purity, diluted, hydrochloric acid (HCl) is also provided to field staff for preservation of the sample.

A two-person team, as described in Method 1669, is used for sample collection. One member of the two-person sampling team is designated as "Dirty Hands," and the second member is designated as "Clean Hands." The individual designated as "Clean Hands" will handle all operations involving contact with the sample bottle and transfer of the samples from the sample collection device to the sample bottle. "Dirty Hands" is responsible for the preparation of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample. Sampling teams wear clean non-talc gloves as well as clean, lint-free, outer clothing to protect samples from contamination by lint and dust.

Special precautions are incorporated to minimize contamination. When possible the facility history and results showing previous results of mercury levels at specific locations are used to design the collection process, in order to minimize the chances of cross contamination. Where decontamination of the equipment is required, equipment blanks are taken before each sample. Sample collection is performed by a strict protocol designed to minimize contamination.

Because of the likelihood of positive blanks and the affect they have upon the results, staff should carefully evaluate blank levels before making regulatory decisions. For application to regulatory requirements, it is recommended that blank mercury levels be less than one-fifth of the mercury in the associated sample. This is the guideline recommended in Method 1631.

Definitions

1. Trace Metal Grade Reagents – Reagents that make no significant contribution of mercury to the sample.
2. Dirty and Clean Hands: All operations involving contact with the sample bottle, and transfer of the samples from the sample collection device to the sample bottle, are handled by the individual designated as "Clean Hands." An individual designated as "Dirty Hands" is responsible for the preparation of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample.

Contamination and Interferences

The need to avoid contamination when collecting samples for extremely low level measurements cannot be over emphasized. Field collection personnel should be familiar with the potential sources of mercury contamination, and implement those steps necessary for adequate control. Field and equipment blanks are used to discover contamination problems during the collection steps.

1. Potential Sources of Mercury Contamination: These include metallic and metal-containing equipment, containers, lab ware, reagents, and de-ionized water, improperly cleaned, and stored equipment, as well as atmospheric sources such as dirt and dust, automobile

exhaust, laboratory workers, and cigarette smoke. Well construction materials, e.g., the gravel pack and well screen, may also be a source of contamination.

2. Potential Contamination from Well Construction Materials: Levels of mercury in groundwater samples can be a result of natural background, well construction material, or environmental contamination. To reliably distinguish the mercury contribution of both natural background and well construction materials from environmental contamination, measurements from up-gradient background wells, constructed in the same manner as down-gradient wells, are necessary. RRD Operational Memorandum No. 4 provides guidance on establishing background.
3. Use of Peristaltic Pumps: Peristaltic pumps have distinct advantages in controlling contamination, and should be used when possible. Most other pumps have metal parts that may come in contact with the sample; hence, pumps must be decontaminated. For peristaltic pumps, only the tubing is in contact with the sample: consequently, clean tubing is all that is necessary to minimize contamination.
4. Control: The best way to control contamination is to minimize exposure of the sample and sampling equipment to possible sources of contamination. When possible, prior knowledge of mercury levels at sampling locations is used for planning collection activities to minimize chances of contamination from high sources, cross contamination resulting from sequentially sampling locations of high and low levels, and cross contamination during storage and transportation. Appropriate equipment and field blanks are used to discover contamination.
5. Filtering: If filtering is determined necessary (see RRD Operational Memorandum No. 2, Attachment 5 for direction on filtering) it must be performed at the laboratory to prevent contamination.
6. Preservation: Preservation at the laboratory is optional for samples not requiring filtering. Unpreserved samples should be sent to the laboratory overnight.

Apparatus and Materials

1. Disposable Materials: Disposable materials such as gloves, storage bags, and plastic wrap, may be used new without additional cleaning unless the equipment blank results identify any of these materials as a source of contamination. If new disposable materials are found to be a source of contamination, then a different supplier must be obtained or the materials must be cleaned.
2. Sample Bottles: Fluoropolymer (FEP, PTFE) or borosilicate glass, 125 ml to 1 L, depending upon laboratory specifications with fluoropolymer or fluoropolymer lined caps, cleaned according to Method 1669/1631 procedures, with air tight cap. Containers are filled with 0.1 percent HCl (v/v), tightly capped, double bagged in new polyethylene zip-type bags until needed, and stored in cardboard boxes until use. Sample bottles are transferred to the facility with 0.1 percent HCl, or emptied and filled with reagent water for transportation.
3. Tubing for use with low-flow sampling pump: Use fluoropolymer tubing in lengths as required to reach the sampling point. Tubing must be cleaned by soaking in a 5-10 percent HCl solution for 8-24 hours, rinsing with reagent water in a clean bench in a clean room, and drying in the clean bench by purging with mercury-free air or nitrogen. Tubing must be double-bagged in clear polyethylene bags, serialized with a unique number to identify it in case of contamination problems, and stored until use.
4. Peristaltic Pump: 115V A.C., 12V D.C. internal battery, variable-speed, single head, Cole-Palmer or equivalent, portable, "Masterflex L/S," Catalog No. H-07570-10 drive with Quick Load Pump head, Catalog No. H-07021-24, or equivalent.
   a. Tubing for use with peristaltic pump. Styrene/ethylene/butylene/silicone (SEBS) resin, approximately 3/8 in. internal diameter (i.d.) by approximately 3 ft., Cole-Palmer size 18,

Cat. No. G-06464-18, or approximately ¼ in. i.d., Cole-Palmer size 17, Catalog No. G06464-17, or equivalent. Tubing is cleaned and stored as provided above.

b. Tubing for connection to peristaltic pump as provided above. Fluoropolymer, 3/8 or ¼ in. outside diameter (o.d.), in lengths required to reach the point of sampling. Tubing is cleaned and stored as provided above. If necessary, more aggressive cleaning (e.g., concentrated nitric acid) may be used.

5. Bladder Pump: QED[1] model MP-SP-4P.
   a. Water Level Meter – Provided as part of the QED bladder pump equipment, QED part number MP30-150.
   b. Controller – Provided as part of the QED bladder pump equipment, QED part number MP-15.
   c. Bladders – QED Bladder Kit, part number 38360. Unless it is known, the bladders do not contribute to contamination, the bladders must be cleaned and stored as provided above.
   d. Spare CO2 Tank – QED part number 38304.
6. Water Quality Instruments: Use instruments capable of measuring temperature, hydrogen ion activity (pH), specific conductance, redox, dissolved oxygen, and turbidity to determine when formation water is entering the pump. With the equipment provided to staff, a separate meter is necessary for turbidity measurements.
7. Gloves: Clean, non-talc polyethylene, latex, vinyl, or polyvinylchloride (PVC): various lengths.
8. Gloves: PVC—Fisher Scientific Part No. 11-394-100B, or equivalent.
9. Wind Suit: Suitable to protect samples from contamination from lint and dust. Unlined, long sleeve wind suit consisting of pants and jacket constructed of nylon or synthetic fiber are suitable. Tyvek® suits are used in this procedure.
10. Storage bags: Clean, zip-type, non-vented, colorless polyethylene (various sizes). Large size bags are needed for storage of the pump during transportation between sampling locations.
11. Plastic Wrap: Clean, colorless polyethylene.
12. Cooler: Clean, nonmetallic, with white interior for shipping samples.
13. Ice: Use ice to keep samples chilled during shipment. Chemical packs are less effective.
14. Carboys: Dedicate one specific carboy for "Reagent Water."
15. Plastic Decontamination Tubs: Containers of various sizes to immerse the submersible pump, sampling tubing, and the wetted parts of the water level meter and multi-parameter monitor. Four tubs are needed, one for a soap solution, one for tap water rinse solution, one for reagent water rinse, and one to hold the reagent water for obtaining field blanks.
16. Pipette: Automatic pipette, capable of dispensing 10.0 ml and automatic tip ejector.
17. Pipette Tips: Colorless, 10 ml, for use with automatic pipette. Pipette tips must be cleaned and stored as described under tubing above.

Reagents

1. Reagent Water: Ultra pure deionized water, starting from a pre-purified (distilled, reverse osmosis, etc.) source, 18 Megaohms minimum, provided in a carboy suitable to prevent mercury contamination. The water should be tested at the laboratory for suitability for sampling. The quantity needed depends on the amount of water needed for each decontamination cycle and the number of wells sampled. The laboratory should provide this water.
2. Preservative: Hydrochloric acid (HCl), 6 N (normal) made from Trace Metal Grade acid and reagent water, and tested to contain less than 0.5 ng/L of mercury. The laboratory should provide this reagent.

3. Soap: Alconox [2] CITRANOX®, suitable for cleaning instruments for low level mercury sampling. Prepare a 2 percent solution as per the manufacturer's instructions.

Site Sampling Plans and Sample Delivery Strategies to Minimize Contamination

1. Sample Collection Strategy: Sample collection activities should be designed that will minimize the potential for cross contamination.
   a. If possible, use previous facility data showing mercury levels at the locations to be sampled. If mercury data is not available, use other information to make a judgement whether the mercury level is suspected to be high or low. For example, if data is available for other metal levels, the relative levels of these metals may be a good indicator of whether high or low mercury levels are suspected.
   b. Arrange the sampling sequence in order of their known or expected levels of mercury. Collect samples starting from locations known to have the lowest and approximate same levels of mercury, and proceed to those of higher levels. In this manner, if decontamination procedures fail to remove all residual mercury, the effect on samples will be minimized.
   c. Group samples so that samples of high and low levels are separately grouped in storage and transportation. For purposes of separating samples based on expected concentration levels, samples believed to have concentrations more than 200 ng/L of mercury should be identified as high level samples, and low level samples less than or equal to 200 ng/L.
2. Sample Information Provided to the Laboratory: Laboratory areas and instrumentation used for low level analysis of mercury are extremely clean and designed to prevent mercury contamination from outside sources. Processing a sample with an extremely high level of mercury in these areas can result in contamination of the area and instrumentation, resulting in delays and additional expense. Using the evaluation described above, provide information to the laboratory regarding the known or expected levels of mercury for each location sampled. Information useful to the laboratory and recommended to be provided is as follows:

Mercury (Hg) Level	Provide to Laboratory
Hg levels not known and high levels expected.	Expected > 200 ng/L
Hg levels not known and low levels expected.	Expected < 200 ng/L
Hg levels previously found	Provide Data
Hg levels and expectations not known	Not Known

Sample Collection, and Handling Considerations

Sampling precautions should be taken as follows:
1. Use low-flow rates (0.5 L/min.) during both purging and sampling to maintain minimal draw-down in the well.[3]
2. Place the sampling pump intake at the proper sampling point.
3. Minimize disturbance of the stagnant water column above the screened interval during water level measurement and sampling device insertion.
4. Make proper adjustments to stabilize the flow rate as soon as possible.
5. Monitor water quality indicators during purging.
6. Collect unfiltered samples to represent contaminant loading and transport potential in the subsurface system.

7. Filtering (if necessary): If it is not feasible to collect samples representative of the water flowing in the aquifer, and filtering is determined necessary, (see RRD Operational Memorandum No 2 – Attachment 5 for direction on filtering), collect duplicate samples and identify one of these to be filtered and preserved upon receipt at the laboratory. Appropriate arrangements must be made with the laboratory to ensure the filtering and subsequent preservation is accomplished for identified samples immediately upon receipt. Arrangements with the laboratory to utilize appropriate filters should be made well in advance of sample collection, so that immediate filtering and preservation at the laboratory can be accomplished upon receipt of samples.
8. Water samples should not be taken immediately following well development. Sufficient time should be allowed for the groundwater flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on facility conditions and methods of installation but often exceeds one week.
9. Well purging is nearly always necessary to obtain samples of water flowing through the formation associated with the screened interval. The required purging procedure relies on the stabilization of several water quality parameters to determine when formation water is being pumped. The pH, specific conductance, redox, dissolved oxygen, and turbidity are monitored for this purpose. Temperature is also measured and recorded during this process but is not used as an indicator for formation water. Data on pumping rate draw-down, not to exceed 0.1 meter, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.
10. Water Level Measurements and Monitoring: Well depth should be obtained from the well logs. Since measuring to the bottom of the well casing will cause re-suspension of the settled solids and require longer purging times for turbidity equilibration, measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point, which is surveyed relative to ground elevation.

Sample Collection using Bladder Pumps

1. Upon arrival at the sample location, one member of the two-person sampling team is designated as "Dirty Hands," and the other as "Clean Hands."
2. An area, expected or known to be free of high levels of mercury, is selected.
3. The team removes the bags containing the pump, monitoring instruments, tubing, carbon dioxide (CO_2) cartridges, gloves, plastic wrap, and wind suits, from the coolers or storage containers in which they are packed.
4. The team puts on Wind Suits and PVC gloves.
5. The team generates the Initial Equipment Blank, following the steps listed under Decontamination and Initial Equipment Blank.
6. The team proceeds to the sampling location.
7. The team opens the well.
8. The team changes gloves.
9. Keeping both bags together, Dirty Hands opens the outer bag containing the pump.
10. Clean Hands opens the inner bag and removes the pump.
11. Clean Hands lowers the submersible sampling pump into the monitoring well. Lower the pump slowly and carefully to the middle of the screened interval or slightly above the middle. This should minimize excessive mixing of the stagnant water above the screen with water in the screened interval and minimize suspension of solids from the bottom of the well.
12. Dirty Hands opens bag containing static water level meter. Clean Hands removes water level meter. Clean Hands sets up the water level meter.

13. Clean Hands connects the multi-meter flow through cell to the pump outlet.
14. Dirty Hands turns on the submersible pump, sets the pump for the allowable water level draw-down (not to exceed 0.1 meters), and slowly pumps the water while monitoring the water level to assure that that the pumping rate does not result in draw-down of the water level. With the QED bladder pump in this standard operating procedure (SOP), the pump will turn off automatically if this level is exceeded. As the well is pumped, water quality parameters are monitored to determine when formation water is flowing through the pump. Formation water is considered to be flowing, if three consecutive measurements of the water quality parameters, conducted at 3-5 minute intervals, meet the following requirements:
    a. Turbidity, within ± 10 percent.
    b. pH, within ± 0.1 pH units.
    c. Specific conductance, within 3 percent.
    d. Redox, within ± 10 millivolts
    e. Dissolved oxygen, within ± 10 percent. If dissolved oxygen is used for comparison to criteria or a mixing zone calculation, the dissolved oxygen calibration must be corrected for local barometric pressure and elevation. The equipment in this procedure (YSI multi-parameter meter) automatically corrects the dissolved oxygen for these conditions.
15. After stabilization, Clean Hands disconnects the meter.
16. The team changes gloves.
17. Dirty Hands retrieves the sample containers required, and unzips their outer bags. Retrieve two sample containers if filtering is required, for duplicate samples, or for field blanks. If split samples are to be generated a larger size container is required, at least twice the size of normal samples.
18. Dirty Hands prepares the label(s).
19. Clean Hands opens the inner bag, removes the sample container, and reseals the inner bag.
20. Clean Hands removes the cap for the sample being collected, and while holding the cap upside down, discards the diluted acid into a waste carboy, or empties the reagent water onto the ground.
21. If a field blank is being generated, proceed as follows:
    a. Clean Hands opens the inner bag and places the emptied sample bottle and its cap in its inner bag. This bottle is to be identified as the field blank.
    b. Clean Hands obtains another sample bottle from its inner bag, removes and, discards its cap.
    c. Clean Hands retrieves the field blank bottle, and pours the contents of the sample bottle into the field blank bottle.
    d. Skip to step 27 below.
22. Clean Hands rinses the sample bottle and cap three times with the formation water flowing from the pump, and collects the sample from the flowing tube.
23. Clean Hands caps the sample, opens the inner bag, and places the sample in its inner bag.
24. If filtering is required or a duplicate sample is to be taken, Steps 18 through 23 are repeated to immediately take another sample.
25. For samples required to be filtered or preserved at the laboratory, skip to step 27 below.
26. Preserve each sample taken as follows:
    a. Dirty Hands opens the outer bag containing the preservative, pipette, and tips.
    b. Clean Hands opens the inner bag, opens the preservative, retrieves the pipette, and prepares it for dispensing.

c. Use the information included in Sample Preservation and Holding Time for the correct amount of preservative. Clean Hands pipettes the required amount of preservative into the sample container(s), ejects the pipette tip into the waste container, places the pipette back into its inner bag, recaps the preservative, and seals the inner bag.
d. Dirty Hands seals the outer bag for the preservative.

27. Clean Hands caps the sample(s), opens the inner bag(s) for the sample(s), places the sample bottle(s) into the inner bag(s), and seals the inner bag(s).
28. Dirty Hands seals the outer bag(s), writes sample identification information in permanent ink on the outside of the plastic bag, places the sample(s) in the cooler (on ice), and closes the cooler.
29. Dirty Hands measures and records the depth to the bottom of the well.
30. Dirty Hands records the sample number(s) in the sampling log, water quality parameters, and notes any unusual observations.
31. Clean Hands removes the equipment from the well, removes the water level meter, and places them into bags for transportation.
32. Both Dirty and Clean Hands move to the decontamination area with the equipment.
33. Decontamination Between Sampling Locations steps are used to decontaminate the equipment.
34. Generating the Equipment Blank steps are used to collect an equipment blank.
35. If other samples are to be taken at the facility, the team proceeds to the next sampling location, and collects another sample beginning with step 6 above.
36. If samples are to split, proceed as follows:
    a. The team selects a suitable place for splitting samples.
    b. The team changes gloves.
    c. Dirty Hands opens the cooler, removes the bag containing the sample to be split. The volume of this sample must be at least twice the volume of normal samples.
    d. Dirty Hands removes two bags with sample containers, and unzips their outer bags. These containers will hold the split samples.
    e. Dirty Hands prepares the label(s).
    f. Clean Hands opens the inner bags holding all containers, removes the containers, removes the caps of all containers and places them in their respective inner bags.
    g. Clean Hands discards the diluted acid from the two sample containers, into a waste carboy, or empties the reagent water onto the ground.
    h. Clean Hands pours from the container holding the sample to be split, into each of the sample containers.
    i. Clean Hands discards the container that held the sample to be split.
    j. Clean Hands retrieves the caps, seals the samples with their respective caps, places the samples into their inner bags, and seals the inner bags.
    k. Dirty Hands seals the outer bag(s), writes sample identification information in permanent ink on the outside of the plastic bag, places the sample(s) in the cooler (on ice), and closes the cooler.
    l. Equipment blanks associated with the respective samples must be provided to both parties receiving split samples.
    m. Repeat steps for each additional split sample.
    n. Information specific for splitting samples must be documented. If others request split samples, use the MDEQ Laboratory's chain of custody sheet. If the MDEQ is requesting the split sample, and a chain of custody is not forthcoming from the sampler, use the MDEQ chain of custody, fill out information, sign it, and request this be signed by the provider of the samples.

Sample Collection using Peristaltic Pumps

1. Upon arrival at the sample location, one member of the two-person sampling team is designated as "Dirty Hands," and the other as "Clean Hands."
2. The team opens the well to be sampled.
3. An area, expected or known to be free of high levels of mercury, is selected. Sampling should proceed from lowest to highest expected level of contamination.
4. The team removes the bags containing the pump, batteries, monitoring instruments, SEBS resin tubing, gloves, plastic wrap, and wind suits, from the coolers or storage containers in which they are packed.
5. The team puts on Wind Suits and PVC gloves.
6. Dirty Hands removes the pump from its storage bag and opens the bag containing SEBS resin tubing.
7. Clean Hands installs the tubing in the well. Lower the tubing slowly and carefully to the middle of the screened interval or slightly above the middle, to minimize excessive mixing of the stagnant water above the screen with water in the screened interval, and to minimize resuspension of solids from the bottom of the well.
8. Clean Hands installs tubing on the pump.
9. Dirty Hands opens bag with water level meter.
10. Clean Hands removes water level meter and lowers it into the well.
11. Clean Hands connects the multi-parameter meter flow through the cell to the pump outlet.
12. Dirty Hands turns on the peristaltic pump and slowly pumps the water while monitoring the water level to assure that that the pumping rate does not result in excessive draw-down of the water level (not to exceed 0.1 meters). As the well is pumped, water quality parameters are monitored to determine when formation water is flowing through the pump. Formation water is considered to be flowing if three consecutive measurements of the water quality parameters, conducted at 3-5 minute intervals, meet the following requirements:
    a. Turbidity, within ± 10 percent.
    b. pH, within ± 0.1 pH units.
    c. Specific conductance, within 3 percent.
    d. Redox, within ± 10 mv.
    e. Dissolved oxygen, within ± 10 percent. If dissolved oxygen is used for comparison to criteria or a mixing zone calculation, the dissolved oxygen calibration must be corrected for local barometric pressure reading and elevation. The equipment in this procedure (YSI multi-parameter meter) automatically corrects the dissolved oxygen for these conditions.
13. After stabilization, Clean Hands disconnects the meter.
14. The team changes gloves.
15. Dirty Hands opens the cooler containing the sample bottle, and unzips the outer bag containing the sample container. If the sample is to be split, a larger size container is required at least twice the size of normal samples. If filtering is necessary, a field blank is being generated, or a duplicate sample is to be taken, Dirty Hands unzips the outer bag of another sample container.
16. Dirty Hands prepares the sample label(s).
17. Clean Hands opens the inner bag, removes the sample container, and reseals the inner bag.
18. Clean Hands unscrews the cap, and while holding the cap upside down, discards the diluted acid into a waste carboy, or empties the reagent water onto the ground.
19. If a field blank is being generated, proceed as follows:

a. Clean Hands places the sample bottle and its cap in its bag. This is to be identified as the field blank.
b. Clean Hands obtains another sample bottle from its bag, unscrews and discards the cap.
c. Clean Hands retrieves the field blank bottle, and pours the contents of the other bottle into the field blank bottle, discards this other bottle, retrieves the cap of the field blank and caps the field blank.
d. Skip to step 22 below.

20. Clean Hands rinses the sample bottle and cap three times with the formation water, and collects the sample from the flowing tube.
21. Clean Hands caps the sample.
22. Clean Hands places a label on the sample container, and places it in its inner bag.
23. If filtering is required, or a duplicate sample is to be taken, steps 17 through 22 are repeated to immediately take another sample.
24. For samples required to be filtered, and samples requiring preservation at the laboratory, skip to step 26 below.
25. Preserve sample as follows:
    a. Dirty Hands opens the outer bag containing the preservative, pipette, and tips.
    b. Clean Hands opens the inner bag, opens the preservative, retrieves the pipette, prepares it for dispensing, and pipettes the required amount of preservative into the sample container(s). Use the information included in Sample Preservation and Holding Time for the correct amount of preservative.
    c. Clean Hands ejects the pipette tip into the waste container, places the pipette back into its inner bag, and seals the inner bag.
    d. Clean Hand caps the preservative, places it in its inner bag, and seals the inner bag.
    e. Dirty Hands seals the outer bags for the pipette and preservative.
26. Clean Hands caps the sample(s), opens the inner bag(s) for the sample(s), places the sample bottle(s) into the inner bag(s), and seals the inner bag(s).
27. Dirty Hands seals the outer bag(s), writes sample identification information on the outer bag, places the sample(s) in the cooler (on ice), and closes the cooler.
28. Dirty Hands measures and records the depth to the bottom of the well.
29. Dirty Hands records the sample number(s) in the sampling log, water quality parameters, and notes any unusual observations.
30. Clean Hands removes the equipment from the well, removes the water level meter, and places them into bags for transportation.
31. Both Dirty and Clean Hands move to the decontamination area with the equipment.
32. Decontamination Between Sampling Locations steps are used to decontaminate the water level meter and multi-parameter meter. The SEBS resin tubing is replaced prior to sampling each new monitoring well.
33. If other samples are to be collected, the team proceeds to the next sampling location, and collects another sample beginning with the step 1.
34. If samples are to be split, follow the steps in Sample Collection Using Bladder Pumps, starting with step 36.

Decontamination and Initial Equipment Blank

1. Dirty Hands prepares the decontamination solutions.
2. Dirty Hands opens outer bag containing tubing and pump bladder.
3. Dirty Hands opens bags containing pump and water level meter.
4. Dirty Hands removes the pump.

5. Dirty Hands holds the pump while Clean Hands removes the bladder from the inner bag and places the bladder on the pump. Clean Hands removes tubing from the inner bag and installs tubing on pump and controller.
6. Dirty Hands lowers pump into tub 1 containing the soap solution.
7. Dirty Hands turns on controller and pumps three volumes of soap solution through the pump and tubing.
8. Clean Hands moves the pump to tub 2 containing tap water.
9. Dirty Hands turns on controller to pump three volumes of tap water through the pump.
10. Clean Hands moves the pump to tub 3 and pumps three volumes of reagent water.
11. Clean Hands places the pump in tub 4 containing reagent water.
12. An equipment blank is taken following steps in Generating the Equipment Blank.
13. Clean Hands removes the water level meter from its storage bag, decontaminates the water level meter by successively cleaning with solutions from tub 1, 2, and 3, and places the meter into a clean storage bag.

Decontamination Between Sampling Locations

1. The team changes gloves.
2. Dirty Hands prepares the decontamination solutions.
3. Dirty Hands lowers pump into tub 1 containing the 2 percent Alconox/tap water solution.
4. Dirty Hands turns on controller and pumps three volumes of Alconox solution through the pump.
5. Clean Hands moves the pump to tub 2 containing tap water (fresh tap water should be used between each sampling location.)
6. Dirty Hands turns on controller to pump three volumes of tap water through the pump.
7. Clean Hands moves the pump to tub 3 and pumps three volumes of reagent water (fresh reagent water should be used between each sampling location.)
8. Clean Hands changes gloves.
9. Dirty Hands opens outer bag containing tubing and pump bladder.
10. Dirty Hands changes gloves.
11. Dirty Hands removes the pump from tub 3.
12. With Dirty Hands holding the pump, Clean Hands removes the bladder from the inner bag and places the bladder on the pump. Clean Hands removes tubing from the inner bag and installs tubing on pump and controller.
13. Clean hands places pump in reagent water in tub 4.
14. The team changes gloves.
15. An equipment blank is taken following steps in Generating the Equipment Blank.
16. Clean Hands places the pump in the storage bag or proceeds to place pump in monitoring well.
17. Clean Hands removes the water level meter from its storage bag, decontaminates the water level meter by successively cleaning with solutions from tub 1, 2, and 3, and places the meter back into a clean storage bag or into the monitoring well.
18. Clean Hands changes gloves.

Generating the Equipment Blank

1. One equipment blank is generated for each location sampled.
2. With the submersible pump in tub 4 holding the fresh reagent water, Dirty Hands turns on the pump and allows several volumes of reagent water to be pumped.
3. The team changes gloves.

4. Dirty Hands opens the box or cooler containing the sample bottles, and unzips the bag containing a sample container. If a split sample is scheduled to be taken, Dirty Hands unzips another bag containing a sample container.
5. Clean Hands opens the inner bag, removes the sample container, and reseals the inner bag.
6. Dirty Hands reseals the outer bag.
7. Clean Hands unscrews the cap, and while holding the cap upside down, discards the diluted acid into a waste carboy, or empties the reagent water on the ground.
8. As reagent water is flowing through the pump, Clean Hands collects the sample by emptying the solution from the sample bottle, rinsing the sample bottle and cap three times with the flowing reagent water, and collecting the sample from the flowing tube.
9. If preservation is performed at the laboratory, skip to step 11.
10. Preserve sample(s) as follows:
    a. Dirty Hands opens the outer bag holding the automatic pipette and preservative.
    b. Clean Hands opens the inner bag containing the preservative and automatic pipette, opens the preservative bottle, and pipettes 10 ml of the preservative into the sample bottle.
    c. Clean Hands recaps the preservative bottle, removes the pipette tip, and places the preservative and pipette back into its bag.
    d. Clean Hands seals the inner bag holding the preservative and pipette.
    e. Dirty Hands seals the outer bag.
    f. Clean Hands opens the inner bag for the sample, places the sample bottle into the inner bag, and seals the inner bag.
11. Dirty Hands seals the outer bag, opens the sample cooler, places the equipment or field blank in the cooler (on ice), and closes the cooler.
12. Dirty Hands records the sample in the sampling log as the "Equipment Blank".
13. If the scheduled sample to be taken is a split sample, follow the steps in Sample Collection Using Bladder Pumps, starting with step 36.
14. Clean Hands removes the pump from the tub, places it in a clean protective bag, and seals the bag.

Sample Preservation and Holding Time

1. Preservation: Samples are transported on ice during shipment to the laboratory. Samples are preserved in the field using 10 ml/L 6N HCl per liter of sample. If filtering and preservation is required at the laboratory, equivalent amounts of HCl per liter of sample can be used.
2. Laboratory Processing of Filtered/Preserved Samples: If filtering and preservation is to be performed at the laboratory, make arrangements with the laboratory for receipt of samples well in advance. If special filters are necessary, these must be provided to the laboratory prior to sample collection activities or arrangements made with the laboratory to ensure they are available upon sample receipt. It is not advisable to plan sampling immediately proceeding non-working days for the laboratory. Upon shipment of samples to a laboratory, it is good practice to immediately contact the laboratory. If the laboratory is not advised of these arrangements, extra effort and expense must be incurred to ensure necessary filtering and preservation.
3. Sample analysis must be performed within 28 days of sample collection.

Quality Assurance/Quality Control

Equipment Blank: The equipment blanks are used to verify the equipment is free from contamination prior to the collection of the sample. (See Decontamination and Initial Equipment Blank and Generating the Equipment Blank)

1. Frequency of Collection: Collect one initial equipment blank, and an equipment blank per monitoring well sampled.
2. Evaluation Criteria: If the mercury concentration in the blank is greater or equal to 0.5 ng/L, or greater than one-fifth of sample concentration, whichever is higher, the associated sample result is an estimate and may be unusable for regulatory application.
3. Corrections: If the initial equipment blank indicates contamination, above 0.5 ng/L, review the process used for cleaning, and have reagents replaced as appropriate.

Field Blanks: The purpose of field blanks is to assess the suitability of the container, preservative, and sample handling. The field blank is generated by simply pouring the solution provided in one of the sample containers into another sample container whose contents have been emptied at the facility. (See Sample Collection Using Bladder Pumps step 21 and Sample Collection using Peristaltic Pumps step 19)

1. Frequency of Collection: One per facility, per day, or one per sampling event, whichever is greater.
2. Evaluation: If the mercury concentration in the blank is greater or equal to 0.5 ng/L, or greater than one-fifth of sample concentration, whichever is higher, the associated sample result is an estimate and may be unusable for regulatory application.

Field Duplicates: The purpose of field duplicates is to assess the precision for the field sampling and analytical process. A field duplicate is collected by filling a second sample container, in rapid succession after the first sample, from the outlet of the sampling stream.

1. Frequency of Collection: Collect duplicates minimally for every 10 samples collected, or at the frequency specified in the project objectives. If possible, select a location with detectable amounts of mercury.

Split Samples: Split samples are used to independently confirm results of the laboratory performing the analysis. Typically a laboratory known to produce valid, unbiased results, is selected as the laboratory to which the split samples are sent.

1. Collection: Split samples are created by dividing one sample collected in the field into two aliquots. This requires the collection of at least twice the volume of sample normally collected, properly preserved if field preservation is performed. Because of the influence that equipment blanks may have upon the use of the data, an equipment blank associated with the sample should be provided along with the split sample. This will require the generation of two equipment blanks prior to the collection of the sample to be split.

Footnotes

1. QED, P.O. Box 3726, Ann Arbor, MI 48160.
2. Alconox, Inc., 30 Glenn Street, Suite 309, White Plains, NY, 10603.
3. Puls, R. W. and Barcelona, M. J. 1996 Low-Flow (Minimal Draw Down) Ground-Water Sampling Procedures, EPA Ground Water Issues, U.S. EPA Office of Research and Development, EPA/540/S-95/504.

Disclaimer

Mention of specific manufacturers and associated instruments does not constitute endorsement by the MDEQ RRD of that manufacturer and equipment.

This SOP is intended to be a performance-based method. Acceptance of results using modifications of this procedure, and using other procedures, will depend upon the demonstration of equivalent performance.

ARCADIS

Appendix D-3

USEPA Low Stress (Low Flow)
Purging and Sampling Procedure
for the Collection of Ground Water
Samples from Monitoring Wells

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

July 30, 1996
Revision 2

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permealability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and

total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator

parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values

measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter

size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII. FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and

detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

EXAMPLE (Minimum Requirements) Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____ Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (stand in for Eh).